FINAL REPORT

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FILTRATION OF RUNOFF FROM PRESSURE WASHING VESSEL HULL IN DRYDOCK

Prepared by

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(NASSCO)

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FOREWORD

This guide on filtration of runoff from pressure washing vessel hulls in dry dock was produced for the National Shipbuilding Research Program as a cooperative cost sharing effort between the U.S. Navy and National Steel and Shipbuilding Company (NASSCO). The Facility and Environmental Effects Panel (SP-1) of the Society of Naval Architects and Marine Engineers (SNAME) Ship Production Committee sponsored the project under the technical direction of Lynwood Haumschilt of NASSCO, NSRP Program Manager.

This guide was prepared by NASSCO with Mr. John Martin acting as Project Manager and Ms. Brooke Davis as author of the guide.

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Dana Austin of Southwest Marine, Inc.
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OBJECTIVES

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The primary objective of this project is to characterize the contamination to help decide the level of treatability that will be required in the removal of the contaminants. From this information, a determination was made about what types of wastewater pretreatment technologies are available to meet the required discharge iimits (NPDES or POTW) for hydroblasting operations on a hull surface at a shipyard dry dock facility. The objective to this project was to identify the most practical and cost-effective methods to filter or treat runoff water from hydroblasting to meet Federal and State water quality requirements or local Public Owned Treatment Works (POTW) standards.

PROJECT OVERVIEW

The approach of this project was to first characterize the runoff that contains the sources of contamination such as paint solids, sediment, spent grit blast, sea growth, and toxic metals. The chemical and physical parameters of the material were defined to decide the sources that had the greatest impact on the water quality. From this data, a determination was made about which selected pretreatment technologies would best meet the required treatment limits for the discharge of hydroblast wastewater.

Since shipyards vary as to facility layout and facility requirements, shipyards around the country were surveyed to determine requirements and whether any pretreatment technology is successfully being applied to their hydroblast wastewater. Past and current research projects were reviewed to provide information for this project. All pretreatment technologies identified for this project have undergone a cost comparison in terms of equipment requirements, operating and maintenance, and facility requirements.

Vendor and water treatment specialists were contacted to assist in the proper identification of treatment technologies. NASSCO and Southwest Marine were used as prototype shipyards to identify and characterize the runoff contaminants.

The development phases of the guide are summarized below:

- Research and collect information on treatment technology
- Contact and interview shipyard and vendors
- Select a prototype shipyard to identify and characterize the runoff contaminants
- From analysis of contaminants, identify possible filtering technologies
- Identify method to contain pressure runoff for storage and treatment
- Select pretreatment technologies for shipyards including cost and benefits
- Develop a final guidance document.

Shipyards should benefit from this study by improving their management of wastewater generated during hydroblastng operations. Shipyards can use this report to help to simplify design and estimate implementation costs of pretreatment. Additionally, the cost analysis portion of this report is designed to result in actual cost savings to shipyards by providing information on test data, design evaluation, and available treatment technologies.

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SECTION 1

INTRODUCTION

The wastewater generated from pressure washing (hydroblasting) vessel hulls in a dry dock facility usually requires treatment before discharge to the local Public Owned Treatment Works (POTW) or directly into the receiving waters. Treatment often requires that the wastewater contaminants, such as paint solids, sea growth, spent grit blast, and sediment be removed before discharge. This requirement is addressed under the facility's National Pollutant Discharge Elimination System (NPDES) or local POTW permit, which allows certain discharges from drydocking facilities at a shipyard. The permit may or may not give specific details about what discharge limits or level of technology is to be used in the treatment of the wastewater.

Therefore, many shipyards have developed their own methods and treatment systems, such as settling tanks, filtration systems, and chemical treatment methods that they believe most economically meet the requirements for treatment of this waste effluent. Sometimes insufficient research was performed to characterize the waste stream and identify the treatment technologies that best meet the needs of the shipyard facility. This approach may not result in the most cost-effective treatment option to meet the required NPDES/POTW permit discharge limits. Without proper characterization of the waste stream, many shipyards are encountering problems with proper identification of treatment technologies to best meet the general needs of the shipyard and simultaneously satisfy the regulatory requirements. Ambiguities in the regulatory requirements further complicate determination of the appropriate treatment technology. This study identifies hydroblasting waste streams and contaminants and surveys potential primary technologies that would facilitate shipyards' abilities to comply with regulations in the most cost-effective manner.

This study is being conducted in two phases to survey technologies for each treatment phase. Phase I of the water filtration study provides information on emerging new technologies and existing pretreatment technology, and provides cost versus benefit comparisons of filtration equipment. Phase II of the study will expand the scope of Phase I by identifying all waste streams and finding the most cost-effective treatment system for particular waste streams, especially heavy metals such as Tributyltin (TBT), Lead, Zinc, and Copper. Additionally, Phase II of the study will find the most effective means of disposal, concentrating on recycling the contained water. This recycling would enable shipyards to reduce their final disposable quantity of waste. Phase II will conclude with the design of a closed loop treatment system which has certain advantages over a batch system. The Phase II study will provide shipyards with an opportunity to compare treatment technologies and select the most practical and cost-effective treatment systems to meet current and future environmentally permissible discharge limits.

The first step in selecting a pretreatment technology is to characterize the hydroblast

waste streams. This characterization was achieved through a literature review, a shipyard survey and sampling events on-site at NASSCO. Optimal filter sizing was found through literature review, shipyard survey, and field tests performed on-site at NASSCO. The most effective means of containing pressure wash runoff was determined using a shipyard survey and literature review. Finally, cost/benefit analyses were done on the cost of filtration versus collection and disposal of the runoff for selected pretreatment technologies.

SECTION 2

SUMMARY OF LITERATURE REVIEW

2.1 Introduction

The objective of the literature search is to compare physical and chemical characterization of hydroblast wastewater done in past studies, and to identify containment and treatment technologies for hydroblast discharges in dry docks. The scope of the literature search is to review characterization of hydroblast wastewater, collection, containment, and pretreatment technologies.

The literature review was primarily conducted at Scripps Institute of Oceanography and the Science and Engineering Library at the University of California at San Diego (UCSD). Other sources include industry contacts, publications, and on-line technical databases, such as the Defense Technical Information Center (DTIC), and the EPA Pollution Prevention Information Clearinghouse Data Base. DTIC contains not only Navy documents, but all military documents.

The Aquatic Sciences & Fisheries Abstracts Data Base at Scripps Library consists of two floppy discs containing abstracts from 1977-1993. Both discs were searched with no resulting documents.

The UCSD on-line computer system, Melvyl, at the Science and Engineering Library., contains several wastewater treatment textbooks for engineers and technical marine journal articles on the treatment of hydroblast wastewater. (See References and Bibliography sections.) Little literature was found regarding containment, collection, and characterization of dry dock waste streams.

Industry sources include shipyard survey participants and NASSCO's in-house experience. Industrial sources produced the most valuable documents

1. "Characterization and Treatability of Hydroblast Wastewater," Alexander, K., Master of Science in Engineering Thesis, Department of Civil Engineering, University of Washington, Seattle, 1988.

2. "Maritime Industrial Waste Project," Municipality of Metropolitan Seattle Water Pollution Control Department, 1992.

3. "Focus Series on Wastewater Treatment," Chemical Engineering Progress, September 1992.

4 "Understanding Water Pollution Laws Governing Chemical Process Industry Plants," Davenport, G.

5 “Developing An Effective Wastewater Treatment Strategy,” McLaughlin, L.

6. “Packaged Wastewater Treatment: An Overview,” Johnson, D., Plant Engineering, June 17,1993.

7. “To Build or Not To Build,” Horton, C., Industrial Wastewater, June / July 1993.

8. “Environmental Pollution Control: Regulatory Considerations and A Case In Point," Ross, J., Journal of Ship Production, August 1993.

The reference lists from these documents were checked and additional literature obtained. (See References and Bibliography). Additionally, a University of Washington Reference Librarian was contacted to find out whether any other theses had been written on the subject of hydroblasting. The librarian was not able to find any other theses on this subject.

The DTIC search did not result in any documents that would be useful for this project. One report was found on the EPA data base, “Development Document for Proposed Best Management Practices for the Shipbuilding and Repair Industry: Drydocks Point Source Category” Effluent Guidelines Division, Office of Water and Hazardous Materials, U.S.E.P.A., Washington, D. C., December 1979.

In conclusion, few research documents were discovered from the literature review. This may be due to a lack of research on this topic since, until recently, hydroblast wastewater was not highly regulated. However, with recent regulatory focus on dry dock discharges, the topic is receiving more attention.

2.2 Regulatory Background

The general trend in the regulatory climate is toward increased regulations with increased focus on industry’s operational practices. The Clean Water Act and the Clean Air Act, and increased local regulatory influences point toward increased requirements and costs for shipyards. Thus, it is important for shipyards to be proactive to ensure compliance and optimize management and costs through good engineering strategies and designs.

Some useful documents for regulatory guidance information are:

1. Code of Federal Regulations 40, Sections 101,301,304,306,307, 402, 501.(8)

2. “Development Document for Proposed Best Management Practices for the Shipbuilding and Repair Industry: Drydocks Point Source Category,” USEPA, 1979, (33) and

3. “Understand the Water-pollution Laws Governing CPI Plants, Focus series on Wastewater Treatment,” Davenport, G., 1992. (10)

For a summary of these documents, the reader may turn to Appendix C for a regulatory overview of the Clean Water Act.

Besides the literature above, the Washington Maritime Industrial Waste Project (23), the California Porter-Cologne Water Quality Control Act (4), and several BMP documents prepared by individual states (Bibliography (6), (9), (29), and (37)) showed trends in the regulatory climate for shipyards. Pending environmental government regulation is being proposed that will affect shipyards in the” future under the new Federal Categorical Standard called Metal Products and Machinery (Phase II) proposed regulation due to be released in 1996-1997.

As regulators gain knowledge of industry operations and as environmental technology evolves, regulatory bodies will increase the amount and scope of regulation and continue to delegate responsibility to local agencies. Although shipyards must comply with federal regulations, shipyards are increasingly affected by compliance with state and local regulatory requirements and discharge limits. For example, in San Diego, California, the State Water Resources Board (SWRB), Regional Water Quality Control Board (RWQCB), and City of San Diego Metropolitan Industrial Waste Program (MIWP) are the state and local water quality agencies. The Porter-Cologne Water Quality Control Act is California’s version of the Clean Water Act, and shipyards discharging to sewer must comply with local MIWP discharge limits, besides state National Pollutant Discharge Elimination System (NPDES) permit limits. In conclusion, prudent shipyards will review their own state and local regulations and evaluate the regulations against their treatment needs.

The delegation of responsibility by the EPA to the state level has resulted in some cases of different standards for various shipyards. In California, as in many other states, the responsibility for NPDES permits has also been delegated to the state by the EPA. As a result, some states allow shipyards to discharge certain dry dock waste streams into receiving waters, and in some states regulations prohibit certain dry dock discharges into receiving water. The Maritime Industrial Waste Project is an example of the trend toward local agencies being involved in providing regulatory oversight in evaluating of effluent discharge routes and the treatment technology required to meet the discharge limits.

> “To date, wastewater discharges from most repair facilities have not been regulated directly. This condition is about to change with the development of new NPDES wastewater permits for these facilities by the Washington State Department of Ecology (Ecology). . .Though its individual NPDES permits and the general permit for boatyards are currently being developed, Ecology has established a policy of eliminating the discharge of untreated

> pressure-washing wastewater to receiving waters and a policy requiring establishment of best management practices at these facilities to prevent the contamination of storm water discharged from these facilities."

Best management practices (BMPs) were initially to be established by the USEPA as part of the NPDES permit. (See Appendix C, Roman Numeral X) In the "Development Document for Proposed Effluent Limitations Guidelines and Standards for the Shipbuilding and Repair Industry," the conclusion is that,

> "This industry is such that numerical effluent limitations are impractical and difficult to apply in a way that could be monitored; therefore, guidance is provided for controlling wastewater pollutant discharges that require that best management requirements be applied."

Ultimately BMI's, along with the NPDES permits, were delegated to the states to develop and most states in turn required shipyards to develop BMPs and provide BIP training for employees. Several BMP documents prepared by individual states (Bibliography (5); (7), (25), (33)) are examples of this trend.

Finally, shipyards must remember that any discharge of any pollutant into navigable waters is unlawful, unless that discharge complies with the Clean Water Act. It is critical that shipyards educate employees in this respect.

2.3 Containment Technologies

Three reports contained information on containment designs and dry dock operations

1. "Environmental Pollution Control: Regulatory Considerations and A Case In Point," Ross, J., 1993.

2. "Development Document for Proposed Best Management Practices for the Shipbuilding and Repair Industry Drydock Point Source Category" USEPA, 1979.

3. "Maritime Industrial Waste Project," Municipality of Metropolitan Seattle Water Pollution Control Department, 1992.

The first article presents a description of approaches to dry dock environmental protection by four facilities: NASSCO, Southwest Marine, and two Navy docks, ARDM 5 and AFDB 10. The main point regarding containment on dry docks is that "the Navy's newest floating dry dock, AFDB 10, will incorporate environmental pollution control features begun at the inception of its design. . . (Significantly). . the two Navy floaters have eliminated abrasive blasting to

eliminate particulate containment curtains. Hydroblasting is used instead." The USEPA document gives a good description of dry dock operations, but does not specifically address containment.

The Maritime Industrial Waste Project had the most useful information regarding containment technologies. The report states,

> "With the exception of a sloped concrete pad similar to those used at truck washing facilities, there are no established collection system designs. The design of collection systems for pressure washing operations is dependent on the type of haul-out used. The deck and sidewalls of most dry docks, for example, already provide the basic containment structure required. The project identified the following components as essential to an effective wastewater collection system:

- Water impervious deck, pad, or other haul-out surface. The surface should slope to a collection sump or trench.
- Adequate wash area to contain all direct and deflected water spray from the wash operation.
- Containment walls, berms, or raised surfaces that allow wastewater to be collected during washing within the containment area.
- A collection sump, trench, or depressed surface area located within the containment area. The sump is used to hold a sump pump and to store wastewater temporarily."

The report included containment designs for cranes, travel lifts, hailer hauls, dry docks, and marine railways. As discussed in Section 3, shipyard survey results universally accepted containment designs consisting of a trench and sedimentation sump. Containment designs are discussed in detail in Section 6. The trench and sump are located on the side and end of the floating dry dock, respectively. The hydroblast wastewater falls directly from the hull to the deck and runs off to the trench and sump. The exception to this design is a cradle liner that is generally used for smaller vessels, which completely segregates the hydroblast wastewater from all other waste streams.

2.4 Hydroblast Wastewater Characterization

The three documents that discussed hydroblast wastewater characterization are:

1. "Characterization and Treatability of Hydroblast Wastewater," Alexander, K., 1988.

2. "Maritime Industrial Waste Project," Municipality of Metropolitan Seattle Water Pollution Control Department, 1992.

3. “Development Document for Proposed Best Management Practices for the Shipbuilding and Repair Industry: Drydock Point Source Category,” USEPA, 1979.

The, “Development Document for Proposed Effluent Limitations Guidelines and Standards for the Shipbuilding and Repair Industry,” includes characterization of, “drainage pump discharges,” of which hydroblast wastewater is a major component. Selected analytical data from the three reports is shown in Table 2-1. The data represents composite highs and lows of several samples for each study. The characterization studies from each of the above documents will be discussed in turn below.

STUDY	SAMPLE	TYPE	P[H]	TURBIDIIY	TSS	VSS	SOLIDS	COD	O&G	Cd	Cr	Cu	Ni	Pb	Zn	Sn	As
METRO	TOTAL	AVG	7.23	176	261	NA	11.00	3202	20	0.01	0.1	12.5	0.05	0.34	6.6	0.34	0.2
	FILTERED	AVG	NA	NA	NA	NA	NA	60	NA	0.034	0.007	0.8	0.01	0.07	0.6	0.05	<DL
	TOTAL	LOW	6.1	3	22	NA	0.70	140	9.9	0.022	0006	0.12	0.01	0.03	0.22	0.06	0.07
	TOTAL	HIGH	8.7	840	693	NA	50.00	740	31	0.05	27	49	0.42	1.7	33	1.6	0.3
	FILTERED	LOW	NA	NA	NA	NA	NA	20	NA	0.033	0.007	0.11	0.01	0.04	0.05	0.05	<DL
	FILTERED	HIGH	NA	NA	NA	NA	NA	200	NA	O.006	0.007	3.6	0.01	0.1	2.1	0.05	<DL
THESIS	SPRAY	LOW	6.3	195	195	80	1.00	160	NA	0.01	0.05	5.6	0.03	0.24	2.6	0	NA
	SPRAY	HIGH	6.4	1500	150)	850	30.00	1200	NA	0.55	0,19	62.2	0.37	1.27	84.8	o	NA
	FALL	LOW	6.2	350	350	20	.070	148	NA	0.002	0.05	8.1	0.03	027	3.3	0	NA
	FALL	HIGH	6.4	1670	1670	630	14.00	2523	NA	0.08	0.31	139.8	0.44	1.26	26.8	1.0	NA
	TOTAL	LOW	6.8	2	2	NA	<0.10	NA	NA	<0.01	<0.025	<0.01	<0.22	1.2	<0.02	0.01	<0.01
	TOTAL	HIGH	8.8	19312	19312	NA	200.00	NA	61	<0.1	10	60.0	60.0	13	39.0	5.0	0.19
	FILTERED	LOW	NA	NA	NA	NA	NA	NA	NA	<0.01	<0.03	<0.04	<O.2	<0.01	<0.02	<0.01	<0.01
EPA	FILTERED	HIGH	NA	NA	NA	NA	NA	NA	NA	<0.1	.79	4..5	<0.2	0.5	4.1	30	0.15

Table 2-1: Hydroblast Wastewater Characterizations from Three Studies

Characterizing hydroblast wastewater that has been completely isolated is much simpler than characterizing hydroblast wastewater mixed with other wastes. For most shipyards, hydroblast wastewater is not completely segregated; it mixes with other contaminants of concern as it runs off toward a sump. Sampling points range from the source (hull) to the sump, and for treatability studies of the composite waste stream, sampling as close to the influent point to the system as possible yields more relevant data. However, for characterizing hydroblast wastewater it is more accurate to sample the water as it ricochets off the hull.

Additionally sample collection techniques, including sampling equipment and decontamination techniques, significantly influence a sample’s integrity, and can

render characterization studies incomparable. Finally, analytical data must be interpreted with respect to the analytical methods used; therefore different analytical techniques may prevent comparisons of characterization data. The Standard Methods for Solid Waste (SW846) by the EPA set the general standards for sample preservation and analytical techniques. Characterization data within the literature must be examined first for the goal of the characterization study, segregation of waste streams during dry dock operations, sample collection techniques, and analytical methods before comparing analytical results.

2.4.1 "Characterization and Treatability of Hydroblast Wastewater," Alexander, K., 1988

Kenneth Alexander's master's thesis titled, "Characterization and Treatability of Hydroblast Wastewater," contains the most complete characterization of hydroblast wastewater. His basic research is the defining body of work on this topic. The goal of the study is specifically to characterize hydroblast wastewater. His observations, similar to the author's experiences, are recounted below

> "On-site inspections and investigations were conducted. . .to become familiar with the operations and layouts of these facilities to develop a sampling strategy and a sense of the physical constraints that must be considered if on-site treatment processes are to be carried out."

The report goes onto discuss dry dock operations during hydroblasting at various shipyards. Efforts were made to collect information on hydroblast equipment used, the duration of water application, and the volumetric flow rates from the hydroblast unit. Other information collected during sampling included the exact type of paint being blasted off, especially whether the antifoulant was copper or tin based, and the hull material.

> . . .no easy method of sampling the hydroblast water was evident. Water was observed to ricochet off the hull surface in all directions, even when attempts were made to deflect the spray to a specific location. The larger the ship, the more widespread the dispersion of the spray. "However, it appeared that the largest volume of water ran down the hull to the lowest point, usually the keel, before falling off the boat. Another significant portion of water ran partially down the hull surface before dripping off at various intermediate locations between the point of application and the lowermost point on the hull. Spray was generated in all directions. These observations suggested a simple and consistent sampling strategy would involve capturing water from all three sources and detecting their respective contributions to the effluent quality and quantity.
>
> "Small grab samples of the hydroblast water were taken and found

to contain small paint chips and, primarily, algae. From the larger steel hulled vessels, occasional large paint chips, rust flakes, and barnacles were found. Generally, whether the water was from a large commercial vessel or a recreational craft, the visible solid particles carried in the water were quite small (<1 mm) and well dispersed in the water. Normally no large chunks, long filaments, and agglomerated masses were observed."

Alexander's sampling method was to place plastic trays (5-8 gallons) in each of the three zones identified: fall, drip, and spray. (See Figure 2-1) "Act each site (shipyard) a small sample of the wash water was collected directly from the hydroblast nozzle for separate laboratory analysis. When the hydroblasting was completed, the water was transferred to 5-gallon plastic buckets, covered, and labeled to describe the water's origin. When practicable, the buckets were returned to the laboratory and if not analyzed immediately, they were placed in a 4-degree Celsius cooler. The sampling trays were washed off immediately with water, inside and out, and thoroughly wiped clean with paper towels at the end of each sampling. Later, they were washed with soap and water, rinsed thoroughly, and dried off with cloth towels."

"Variations in water characteristics within the sampling zones were significant in some cases, but not so in others." There did not appear to be any correlations between concentrations of analytical parameters and sampling zones. Variations in TSS, and COD were significant, but did not correlate to zones. Total suspended solids were generally above 700 mg/L. COD was normally above 800 mg/L. "soluble COD results were quite low (<50 mg/L) for all samples. . .(which) supported the original hypothesis that little dissolved matter was present in the water. Furthermore, it suggested that TBT, if present, was unlikely to be in the soluble phase to a significant extent because of TBT's high octanol-water partition coefficient and the presence of high TSS. . .Six metals were regularly found in concentrations greater than 1 mg/L in both types of wash waters (recreational and commercial vessels). These six metals were aluminum, copper, iron, manganese, lead, and zinc." The highest concentrations of metals in the wash water were copper, zinc, and iron. "The other six metals-barium, chromium, cadmium, nickel, tin, and vanadium-were found in concentrations well under 1 mg/L, although in a few instances tin reached or exceeded 1 mg/L." The thesis also concluded from the analytical results that "tin leached from the paint much faster than the lead and. . that organotin had leached from the paint in significant quantities. . .like tin, chromium was leached from the paint at a higher rate than other metals."

2.4.2 Maritime Industrial Waste Project, Municipality of Metropolitan Seattle Water Pollution Control Department, 1992

The goal of the Maritime Industrial Waste Project was to, "characterize maritime wastewater and identify technologies that would help the industry meet the standard." A telephone conversation with Cynthia Wellner of Metropolitan

Layout of Sampling Trays used to Collect Hydroblast Water and designation of "Spray",, "Drip" and "Fall" Zones Used in Hydroblast Water Characterization

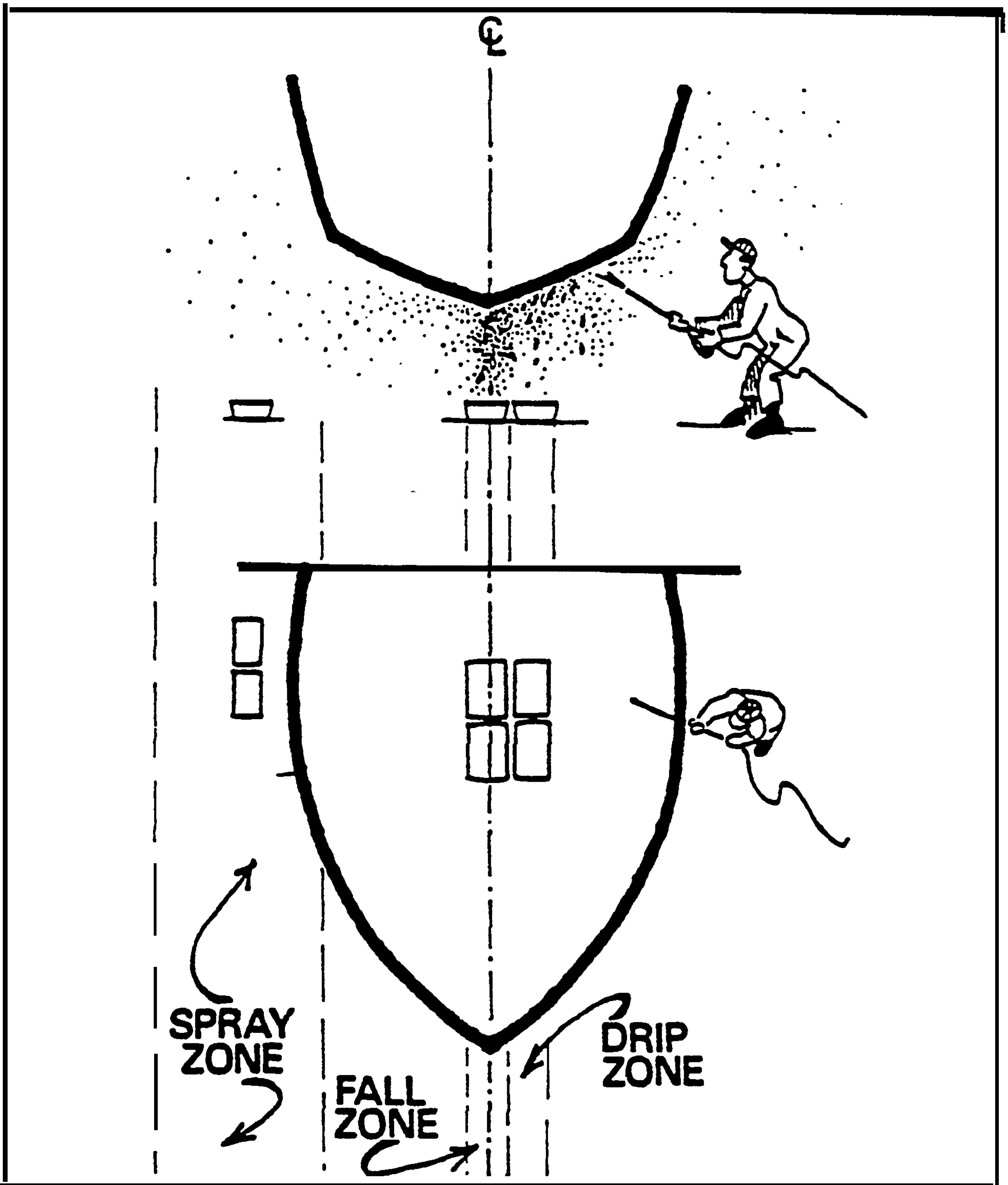


Figure 2-1: Kenneth Alexander's Sampling Method

revealed the samples were collected from the sump of the dry dock and that some vessels' paint systems contained TBT antifoulants, although it was not noted which ones. The Maritime Industrial Waste Project characterization does not discuss operations concurrent to hydroblasting on the dry dock during sampling, nor does it state what kind of containment was in place during hydroblasting, the hydroblast equipment used, the paint system blasted off, or the sample collection technique used. No background (nozzle or harbor) samples were collected. Since the sample was placed directly into the sampling bottle, the possibility for cross-contamination was reduced.

The report discusses the visual characteristics of hydroblast wastewater as follows; "if the paint on the hull being washed is blistered and peeling, the amount of solids removed during washing increases substantially." It further states, "the small particles of paint removed by washing also become interspersed with larger particles of marine growth such as fragmented seaweed and barnacles.

Selected analytical data from the project is shown in Table 2-2. Significant results. were that "total and dissolved fractions of field samples confirmed that the highest percentage of metal contamination in wastewater was contributed by suspended solids. Dissolved metal contamination was low. Based on the average values for total and dissolved metals in...shipyard wastewater showed that suspended solids accounted for 94% of the copper, 80% of the lead, and 91% of the zinc...The survey data showed the average values of COD in hull-washing wastewater to be of the same amount as COD in dilute sewage wastewater. As with metals, COD is contributed mostly by wastewater suspended solids, comprising 80% of shipyard wastewater COD. . .Only a few organic compounds, such as phthalates and polynuclear aromatics (PAHs), were found at low concentration levels-between 10 and 100 ppb-in the samples tested." Phthalates are more likely to originate from the gloves worn during sampling than from ship repair operations. "Oil, grease, and regulated organic compounds were not determined to be problem contaminants in pressure-washing wastewater." The Metro Project concluded that "in general, the average concentrations for copper, lead, and zinc in pressure washing wastewater are near or higher than sewer limit concentrations and from 1 to 2,000 times higher than NPDES receiving water limits, depending on the metal."

The Maritime Industrial Waste Project also did two particle-size/settling experiments that related particle size as a function of settling time, to the concentration of metals in wastewater. The results were, "particles less than 60 microns in diameter contribute about 80-90% of the copper contamination in suspended solids. Particles less than 20 microns in diameter contribute about 50% of the copper. . .The greatest percentage of wastewater suspended solids is less than 50 microns in diameter. . .This finding is important since particles of this size settle out of solution slowly, making simple settling an ineffective means of treatment." Additionally these small particles, "tend to plug surface filters, such as cartridge and bag filters."

ANALYTICAL PARAMETER	UNITS	TOTAL SAMPLE					FILTERED SAMPLE (1)				
CONVENTIONALS		NUMBER OF SAMPLES		MINIMUM (PPM)	MAXIMUM (PPM)	AVERAGE (PPM)	NUMBER OF SAMPLES		MINIMUM (PPM)	MAXIMUM (PPM)	AVERAGE (PPM)
		(2)	(3)				(2)	(3)			
P[H]		39	39	6.1	8.7	7.23-					
CONDUCTIVITY	UMHOS/CM	37	37	96	29,800	3,613					
TURBIDITY	(NTU)	37	37	3	840	176					
SUSPENDED SOLIDS	MG/L	33	33	22	693	261					
SETTLEABLE SOLIDS	ML/L	16	7	0.7	50	11					
coo (4)	MG/L	18	18	140	740	302	12	12	20	200	60
OIL/GREASE	MG/L	5	4	9.9	31	20					
METALS											
CADMIUM	PPM	40	33	0.002	0.05	0.01	17	4	0.003	0.006	0.004
CHROmE	PPM	40	35	0.006	2.7	0.1	17	1	0.007	0.007	0.007
COPPER	PPM	40	40	0.12	49	12.5	17	17	0.11	3.6	0.8
NICKEL	PPM	40	32	0.01	0.42	0.05	17	1	0.01	0.01	0.01
LEAD	PPM	40	28	0.03	1.7	0.34	17	2	0.04	0.1	0.07
ZINC	PPM	40	40	0.22	33	6.6	17	17	0.05	21	0.6
TIN	PPM	23	11	0.06	1.6	0.34	6	1	0.05	0.05	0.05
ARSENIC	PPM	40	4	0.07	0.3	0.2	17	0			

(1) Using a 0.45 micron filter
(2) Total number of samples anafyzed
(3) Number of samples where values were atove detection fimits
(4) Chemical oxygen demand

Table 2-2: Selected Analytical Data from the Project

2.4.3 Development Document for Proposed Effluent Limitation Guidelines and Standards for the Shipbuilding and Repair Industry Drydock Point Source Category

The goal of the EPA guidance document was to characterize drainage discharges, although, “hull cleaning waste was a major component (of). . drainage water.” Recall that the report was written in 1979 and it asserts that hydroblasting is rarely used, and that abrasive blasting is the universally accepted method. Today, as discussed in the next section, hydroblasting is much more commonly used, and the accepted method is to hydroblast for removal of marine growth and loose paint, prior to abrasive blasting to bare metal. The report focused on development of BMPs for dry docks, and sought whether there was a difference in effluent before versus after implementing BMPs. The report concluded, “There is no apparent significant change in Shipyard B’s NPDES monitoring data during,

before, and after clean-up procedures were initiated. It is, therefore, concluded that the nature of the discharge is not conducive to numerical monitoring." The same conclusion was reached for other shipyards' effluent monitoring.

The report discusses sample collection techniques but does not describe visual characteristics of the sample. However, it does discuss in depth the sources and uses of water in dry docks, including a detailed description of which wastes fell to the dry dock floor and cleanup procedures that occurred during sampling. Selected analytical results shown in Table 2-1 are averages of sampling at three shipyards-A, B, and D. The samples were composites collected at the drainage pump discharge. Grab samples of the harbor water were obtained at the time of flooding for each of the sampling events. The report did not discuss specific paint systems contributing to drainage water during sampling.

The study shows that heavy metals were found mostly in the insoluble form. The report concludes, "As in samples at other shipyards, discharge levels tend to be very low with rare 'high' values of certain parameters. It could not be established that dockside activities affect discharge levels. As with Shipyards A and B, constituent levels remain constant throughout. The results again lead to the conclusion that the nature of the discharge is not conducive to numerical monitoring."

The report discussed the obstacles associated with conducting a sampling program of floating and graving docks. The obstacles listed are:

1. "The physical design and operation of a floating dry dock is not conducive to conducting an effective sampling program."

2. "Because only total drainage discharges were monitored on a daily basis, it is difficult to attribute constituents and flows to any individual source or operation."

3. "Insufficient documentation of sampling programs performed prior to this contract makes interpretation of previous monitoring questionable. By failing to explain what shipyard operations were in progress, weather conditions, floor conditions, and especially analytical procedures, interpretation and comparison of monitoring data is difficult."

4. "The lack of a typical daily dock operation means that all data obtained is particular to that specific day and is not necessarily representative of the usual dry dock dischrges."

Leaching studies and sieve analysis were also performed. The leaching studies were too inconsistent and unreliable to lead to conclusions. The sieve analysis is useful because spent grit is often carried by hydroblast wastewater to a sump, and must be treated as an integral part of the waste stream. The sieve analyses

were conducted on fresh grit (Black Beauty) and spent paint and abrasive. "The spent grit and paint, which were collected following a, 'very light sand sweep,' contained flakes and particles of antifouling and primer paints and bits of iron oxides. The test results show that over 95% of the particles in each sample were sand size and were retained in USA Standard Testing sieves numbered 10,40,60, and 140, made by Tyler Equipment Co., with the largest fraction retained in sieve number 40. The unspent grit particles were slightly larger and the facets were sharper and more defined. The specific gravities of the two samples did not differ significantly. These sand-size particles were readily settleable." While the particle size results agree, the conclusion that these small particles are readily settleable does not agree with the conclusion of the Maritime Industrial Waste Project, which asserts that they are not readily settleable.

2.5 Current Treatment Technologies

2.5.1 Definition of Pretreatment

Most of the literature does not define the distinction between pretreatment and treatment, and the term pretreatment is generally not well defined since it is defined differently according to the context in which it is used. In other words, pretreatment is often defined by the user as any treatment that occurred before his receipt of the water. For example, CFR section 403.3 defines pretreatment as,

> "The reduction of the amount of pollutants, the elimination of pollutants, or the alteration of the nature of pollutant properties in wastewater before or instead of discharging or otherwise introducing such pollutants into a POTW. The reduction or alteration may be obtained by physical, chemical, or biological processes, process changes or by other means, except as prohibited by Section 403.6 (d).. Appropriate pretreatment technology includes control equipment such as equalization tanks or facilities, for protection against surges or slug loading that might interfere with or otherwise be incompatible with the POTW. However, where wastewater from a regulated process is mixed in an equalization facility with unregulated wastewater or with wastewater from another regulated process, the effluent from the equalization facility must meet an adjusted pretreatment limit calculated in accordance with Section 403.6(e)."

Most of the classic wastewater treatment textbooks are for municipal wastewater treatment and do not address industrial wastewater treatment. Perry's Handbook for Chemical Engineers, Industrial Wastewater Management section, defines pretreatment as equalization, neutralization, grease and oil removal, and toxic substance removal. Primary treatment is removal of suspended solids and includes screens, grit chambers, gravity sedimentation, and chemical precipitation. Perry's defines secondary treatment as biological treatment that uses

flocculation and gravity sedimentation to remove colloidal soluble organics. Other texts define pretreatment as physical separation, primary treatment as chemical separation, and secondary treatment as any advanced separation technologies. All discussions of hydroblast wastewater treatment will be reviewed below because of the above ambiguities.

Documents containing information on current treatment technologies include:

1. "Characterization and Treatability of Hydroblast Wastewater," Alexander, K., 1988.

2. "Maritime Industrial Waste Project," Municipality of Metropolitan Seattle Water Pollution Control Department, 1992.

3. "Development Document for Proposed Best Management Practices for the Shipbuilding and Repair Industry: Drydock Point Source Category," USEPA, 1979.1. EPA.

2.5.2. "Characterization and Treatability of Hydroblast Wastewater," Alexander, K., 1988

The thesis related treatment studies and discussed potential treatment processes whose selection is based on particle size. These are sedimentation, filtration, screening, and coagulation/flocculation. The thesis addresses treatability of hydroblast wastewater following its characterization. Conclusions on the treatability of hydroblast wastewater are:

1. "Sedimentation does not appear to be an efficient treatment method... This is due to the large number of particles that are present in the size range of less than 40 microns where settling is unlikely to occur. This is also affected by the low density of the majority of the solids."

2. "Screening is only effective as a pretreatment step because most of the particles are too small to be effectively screened out. However, screening does remove larger and more rigid particles where a higher proportion of metals are found. This shows that the paint chips are being screened out more efficiently than the other solids that seem to be primarily algae."

3. "Sand filtration achieved 99% removal of total suspended solids, 9870 removal of chemical oxygen demand and 97+% removal of major metals. However, effluent turbidites ranged from 23 to 45 and effluent suspended solids were about 15 mg/L. Undesirable operating features such as frequent media removal or backwashing due to rapid media clogging make it an ill-suited treatment method for these high TSS waters. Tests with baffles to capture settleable solids inside the filter column showed that pre-settling of the

influent would still result in similar operational problems due to media clogging.

4. "Dual media (anthracite coal/sand) filters produce an effluent comparable to the slow sand filter, although slightly higher in turbidity and suspended solids. They are more favorable than slow sand filtration from an operational standpoint because their solids loading capacity is significantly higher and their media are easier to clean during backwashing. Pretreatment steps such as screening and chemical treatment with aluminum sulfate (alum) appear effective at increasing the dual media filter's ability to accumulate solids and thereby operate more efficiently."

5. "Chemical treatment with alum performs better than any treatment process that was studied. Reductions in total suspended solids approached 100%, chemical oxygen demand removal reached 99%, and soluble chemical oxygen demand was as high as 71% within an optimum dose range of 60-197 mg/L alum and a pH of 7, regardless of the influent water characteristics."

6. "The critical particle size range that relates to treatments effective for these waters is 10-40 microns. This particle size range has a measurable effect on effluent turbidity. Thus the removal of 10-40 micron particles proved to be the critical feature of successful treatment of hydroblasting waters."

Conclusions on treatment alternatives are:

1. "Of all the methods included in this study alum dosing in the range of 60-197 mg/L offers the highest level of treatment performance for on-site hydroblast wastewater treatment. A mixing and settling tank would be a straightforward design effort based on known water volumes and hull-washing schedules. However, this treatment has certain drawbacks including handling and disposal of a large sludge volume (compared to settling alone) and requires greater operator time, skill, and interest to be effective. Because iron salts produce a smaller sludge volume than alum, they should be considered in a chemical treatment process."

2. "More simplified treatment systems, such as a settling tank require less operator time and skill and would be less costly to construct and maintain, but a lower quality treated effluent will result from such a scheme."

3. "High rate direct filtration such as dual media granular filter may be a more desirable treatment option where lower TSS waters are generated in higher volumes and space limitations make large settling tanks impractical. However, backwash requirements for this process could generate water volumes well in excess of the original influent volume. Backwash water would eventually require separation of suspended solids thus introducing another treatment step into the overall process. Backwash requirements must be well

understood before this process is implemented."

4. "Disposing of the wastewater in the sanitary sewer system should be considered as a treatment alternative, particularly when small wastewater volumes such as those generated by a marina are involved."

2.5.3 Maritime Industrial Waste Project

The project "investigated, pilot-tested, and recommended appropriate treatment technologies." Appendix F contains descriptions of treatment systems that were pilot-tested during the Maritime Industrial Waste Project. Conclusions on waste water treatment are:

1. "Treatment for the removal of suspended solids in pressure washing wastewater lowers the concentration of copper, lead, and zinc to acceptable levels for discharge to sanitary sewers."

2. "Treatment for the removal of dissolved metals is required to lower the concentration of copper, lead, and zinc to NPDES limits for discharges to receiving waters. Treatment systems designed to remove dissolved metals were not tested. Possible treatment methods for removal of dissolved metals are reverse osmosis, ion exchange, or distillation."

3. "For two wastewater samples analyzed, settling retention required more than eight hours to settle enough wastewater suspended solids to come close to meeting sewer discharge limits. Ordinary physical settling by itself, therefore, is not an effective method for producing treated effluent that will meet sanitary sewer limits consistently. Enhanced physical settling systems using settling plates or tubes were not tested as stand-alone systems."

The project's conclusions from pilot testing systems are:

1. "of the 11 wastewater treatment systems tested, all were determined to be. capable of treating wastewater to levels below Metro and boatyard NPDES sanitary sewer limits. Five systems used filtration and six systems used chemical flocculation as the main treatment process."

2. "Except for ultrafiltration, filtration processes require settling or chemical coagulation of wastewater solids before filtration to avoid excessive filter maintenance."

3. "No tested treatment system was determined to be capable of treating wastewater to levels below the NPDES receiving water limits for boatyards or shipyards."

4. "Chemical batch treatment using a coagulant such as alum was determined

to be the most adaptable and cost-effective treatment method for small boatyards using 75 gallons of water or less per wash. Chemical and filtration systems operating either as batch or as continuous treatment are effective for larger boatyards and shipyards. To avoid the need for high-volume treatment and holding tanks, large shipyards generating up to 15,000 gallons per day are advised to use a treatment system that operates in a continuous mode."

5. "Bilge water poses a difficult problem for effective, consistent treatment. The treatability of bilge water to remove oil and grease is dependent on the type of materials released to the bilge or used to clean the bilge. Effective treatment by oil/water separation alone can only be successful if emulsifying chemicals are kept from entering the bilge. Bilge water may require several stages of treatment and may not be practical on-site at all if bilge water is regularly emulsified or contaminated with regulated organics."

2.5.4 Development Document for Proposed Best Management Practices for the Shipbuilding and Repair Industry: Drydock Point Source Category

A telephone survey of 38 shipyards and site visits to 7 facilities indicated that treatment and control technology currently in use consists of, "(l) clean-up procedures in the dock, and (2) control of water flows within the dock." Clean-up will not be discussed in this section, although clean up significantly aids segregation of waste streams in dry docks. The report found practices to be widely variable among shipyards. The results showed, "where control and segregation of water flows within the docks are in use or planned the objectives are:

1. To segregate sanitary waste, cooling water, industrial wastewaters, and leakages in order to comply with existing regulations governing sanitary wastes.

2. To comply with existing regulations governing oil spills and discharges.

3. To prevent transport of solids to the waterway and contact of wastewater with debris in the dry dock."

The guidelines defined BMI's based on their findings, and specified that they be incorporated to the NPDES permit as "guidance in the development of a specific facility plan. BMPs numbered 2,5,7, and 10 should be considered on a case-by-case basis for yards in which wet blasting to remove paint or dry abrasive blasting does not occur, and BMP 10 does not apply to floating dry docks." Several of the BMPs focus on clean-up practices and some focus on waste segregation and maintenance:

1. Control of large solid materials
2. Control of blasting debris
3. Oil, grease, and fuel spills

4. Paint and solvent spills
5. Abrasive blasting debris (Graving Docks)
6. Segregation of wastewater flows in dry docks
7. Contact between water and debris
8. Maintenance of gate seals and closure
9. Maintenance of hoses, soil chutes, and piping
10. Water blasting, hydroblasting, and water-cone abrasive blasting (Graving Docks)

The guidelines list the following treatment strategies for dry dock discharges:

1. Baffle arrangement for settling in the drainage system
2. Contained absorbent in drainage discharge flow path
3. Wire mesh in drainage discharge flow path
4. Adaptation of pontoons for settling solids.

However, the guidelines show that of the 30 shipyards contacted, none used these treatment methods. Further, Alexander's thesis (1988) asserts that "in practice, none of these methods had gained wide acceptance by the end of the 1970s and the literature does not indicate arty research into the actual design and construction of such methods has taken place since the BMP guidance document was released." It is possible that these techniques have become more widely implemented since 1988.

SECTION 3

SHIPYARD SURVEY RESULTS

3.1 Methodology

This section presents a summary of the information gathered from surveying 27 shipyards. The objective of the shipyard survey is to determine what pretreatment, if any, is currently being used. Surveys were initially distributed at the National Shipbuilding Research Program SP-1 Panel meeting during October 19-21, 1993, in Maine. Additionally, during the last quarter of 1993, a mailing list was compiled from Waste Minimization Survey participants and Naval Shipyards. The first step in surveying those shipyards on the mailing list was to telephone the contacts and find out their interest in participating in the project. A survey was mailed to everyone who said they would like to participate. Twenty-seven surveys were mailed and twenty shipyards responded—a 74% response. Table 3-1 lists the shipyards that were surveyed and responded. Appendix A shows a sample of the survey form mailed or faxed to participants. A summary of the survey responses from shipyards is presented in Table 3-2.

3.2 Results

Twelve of the twenty responding shipyards reported that they do hydroblasting on underwater hulls-even of the shipyards doing the blasting in-house, four of the shipyards using subcontractors, and one shipyard using a combination of both employees and subcontractors. This is in contrast to the USEPA, "Development Document for Proposed Effluent Limitations Guidelines and Standards for the Shipbuilding and Repair Industry Drydocks Point Source Category," written in 1979, which states, "The almost universally preferred method of preparing steel surface for application of a fresh paint system for salt-water immersion is abrasive blasting. . .Hydroblasting is rarely used in shipyard operations." The 1992 Maritime Industrial Waste Project shipyard survey of shipyards in the Puget Sound area reported that eight out of twenty shipyards, or 36%, do pressure washing. The long term trend appears to be toward hydroblasting, and in particular, in-house hydroblasting as opposed to subcontractors. Current shipyard practice is to scamp off marine growth, hydroblast hull to remove remaining marine growth and loose paint, and abrasive blast to white metal. One might anticipate that in the future shipyards will tend toward higher pressure (>15,000 psi) recycling hydroblast units as a substitution for abrasive blasting. These units are currently used in the aerospace industry; however, they are very expensive (range $50,000 to greater than $100,000). In the future the cost of these units should decrease as more companies offer them and as sales increase. The reason for this trend may be that the cost of containment and disposal is much higher for abrasive blasting than for hydroblasting. Additionally, hydroblasting has reduced risk of worker exposure since the water contains the

SHIPYARDS SURVEYED	HYDROBLAST UNDERWATER HULLS	TREATING HYDROBLAST WASTEWATER IN-HOUSE
ATLANTIC MARINE DRYDOCK	•	
AVONDALE		
BATH IRON WORKS	•	
BAY CITY MARINE, INC.		
CASCADE GENERAL, INC.	•	•
CONTiNENTAL MARITIME		
GD/ELECTRIC BOAT DIVISION		
HONOLULU SHIPYARD, INC.	•	
INGALLS SHIPBUILDING	•	•
INTERMARINE, INC.		
LAKE UNION DRYDOCK	•	•
MARITIME MARINE CORP.		
METRO MACHINE		
NASSCO	•	•
NEWPORT NEWS SHIPBUILDING	•	•
NORSHIPCO	•	
SOUTHWEST MARINE	•	•
TACOMA BOATBUILDING CO.		
TODD PACIFIC, SEATTLE	•	•
WEST STATE, INC.	•	•
TOTALS	12	8

NOTE 20 PARTICIPANTS/17 SHIPYARDS SURVEYED 100%= 74%

TabLe **3-1: Shipyards Responding to Survey**

toxins, and hydroblasting has superior operator safety.

For eight of these shipyards, hydroblasting operations generated more than 100,000 gallons of wastewater per year. It is notable that these results do not agree with the Maritime Industrial Waste Project report which says that “wastewater generation at shipyards averages about 120,000 gallons per year.” The survey average was approximately 846,000 gallons per year, and appears widely variable, depending on shipyard operational practices. The amount of wastewater generated depends on degree of waste segregation and the amount of hydroblasting. Twenty-five percent of the shipyards generate less than 100,000 gallons/year, 25% generate between 100,000 and 500,000 gallons/year, 17% generate between 500,000 and 1,000,000 gallons per year, and 25% generate greater than 1,000,000 gallons per year. (One shipyard’s volume was not available.)

SHIPYARD	SUB OR IN-HOUSE	PRESSURE USED (PSI)	GAL OF WATER GEN/YEAR	WASTEWATER CHARACTERISTICS	CONTAIN WASTEWATER	TREAT WASTEWATER	FINAL FATE OF WASTEWATER	COST TO MANAGE HYDROBLAST WASTEWATER	FUTURE PLANS
SHIPYARD 1	IN-HOUSE	10,000	23,375	PAINT CHIPS, MARINE GROWTH, GRIT BLAST	ONLY WHEN TBT	ONLY WHEN TBT	RIVER	$.12/GAL	UNKNOWN
SHIPYARD 2	IN-HOUSE	3,000	52,500	PAINT CHIPS, MARINE GROWTH, OIL & GREASE	YES	YES	SEWER	$55,000 SET-UP +LABOR	CONTINUE STATUS QUO
SHIPYARD 3	SUB; PLAN IN-HOUSE	2,000; 15,000; 30,000	2,592,000	PAINT CHIPS, SCALE	IN-PROCESS	IN-PROCESS	IN-PROCESS	VERY HIGH	YES; COMPLETE RECYCLING
SHIPYARD 4	SUB	NOT STATED	108,000	PAINT CHIPS	IN-PROCESS	IN-PROCESS	IN-PROCESS	$100,000/YR	DEVELOP RECYCLING W/CLOSED LOOP SYSTEM
SHIPYARD 5	BOTH	4,000-8,000	1,700,000	PAINT CHIPS, MARINE GROWTH, GRAY WATER	IN-PROCESS	IN-PROCESS	IN-PROCESS	VERY EXPENSIVE	CONTINUE TO SEEK TREAT-MENT OPTIONS
SHIPYARD 6	IN-HOUSE	1,500-3,000	NOT AVAILABLE	PAINT CHIPS, MARINE GROWTH	NO	NO	TSDF	$.45/GAL	UNKNOWN
SHIPYARD 7	IN-HOUSE	4,000-30,000	460,800	PAINT CHIPS, MARINE GROWTH, GRIT BLAST	YES	YES	SEWER	<$.01/GAL	CONTINUE STATUS QUO
SHIPYARD 8	SUB	1,500-10,000	750,000	PAINT CHIPS, MARINE GROWTH, GRIT BLAST	YES	YES	SEWER	$.04/GAL	PURCHASE ADDITIONAL SYSTEM
SHIPYARD 9	IN-HOUSE	2,000-3,000	200,000	MILKY APPEARANCE WITH PAINT CHIPS	YES	YES	OCEAN	$.15/GAL	CONTINUE STATUS QUO
SHIPYARD 10	IN-HOUSE	VERY LOW	2,700,000	PAINT CHIPS, MARINE GROWTH, <3% SOLIDS	NO	NO	STREAM	NONE	STORM WATER DIVERSION DEVICE
SHIPYARD 11	SUB	1,500-10,000	540,000	PAINT CHIPS, MARINE GROWTH, GRIT BLAST	YES	YES	SEWER	$1.5-$1.75/GAL	STATUS QUO
SHIPYARD 12	IN-HOUSE	5,000-8,000	86,400	MARINE GROWTH, GRIT BLAST	NO	NO	OCEAN	NEGLIGIBLE	UNKNOWN

Table 3-2: Survey Response Summary

The most common hydroblast wastewater characteristic is paint chips (11 shipyards), followed by marine growth (9 shipyards), and grit blast (5-shipyards). When abrasive blasting and hydroblasting occur concurrently blast media can become entrained in the hydroblast waste stream as the hydroblast wastewater runs off along the deck. Thus the wastewater must be treated for the above constituents.

Only five of the twelve shipyards that do hydroblasting on underwater hulls contain the hydroblast wastewater (one shipyard contains organotin containing hydroblast wastewater on the rare occasions that organotin is on a vessel). Three shipyards are in the process of designing containment and treatment systems. All of the shipyards that contain the water (except one) do so by means of a trench located on the end of the floating dry dock that directs the water to a sump. The only exception to this is the use of temporary darns by one shipyard,

whose situation is complicated by a sectionalized dock.

The same five shipyards that contain the water are the only shipyards currently treating hull hydroblast wastewater. Four of the five shipyards that contain and treat the water, discharge to the sewer. (The fifth discharges to the ocean.) Only one shipyard trucks wastewater to a private industrial waste treatment facility. It is notable that some shipyards that did not do hydroblasting on hulls or contain the water do treat other process waters. In total, ten shipyards do some type of treatment on some type of processed wastewater.

Not all the shipyards listed their sewer limits in the survey, so there was not a complete data set for analysis. However, one important observation is that the limits are widely variable among shipyards. For example, copper limits ranged from 5.8 ppb to 8 ppm and zinc limits ranged from 190 ppb to 10 ppm. Copper and zinc were the most regulated parameters (eight shipyards), followed by nickel, chromium, and lead (seven shipyards), then cadmium and oil and grease (six shipyards), then pH and silver (five shipyards), cyanide (four shipyards), and arsenic and Total Toxic Organics (TTO) (three shipyards). Although no correlation could be found between sewer limits and containment and treatment, it appears that the long term trend is toward lower limits, due to higher analytical technology enabling lower detection limits, and containment and treatment. One explanation for this is that the EPA is mandating more stringent limits on POTWs and receiving waters for discharges, and POTWs are passing along these stricter requirements to shipyards.

The cost per gallon to treat the wastewater was not consistently reported, but for the reported values, the cost/gallon ranged from $.04-$1.75 (Since only composite costs were given in the shipyard survey, the accuracy of this range is not known). Three of the shipyards reported that the testing phase of their process was very expensive, up to $100,000. Four shipyards have achieved costs less than $.15/gallon, and these shipyards all have simple treatment schemes consisting of some combination of settling tanks, oily water separators, flocculants, and filtration systems. It is important to remember that discharge limitations vary widely from shipyard to shipyard. The three shipyards that reported the highest costs are experimenting with new treatment technologies, and it is the testing costs that are the primary cost component. All three of these shipyards have experienced discrepanaeis between the stated capabilities of the technologies and the actual performance capabilities under testing conditions.

For all of the shipyards, oil/water separation is accomplished using settling tanks, some with weir systems, or an oily water separator, and metals removal is accomplished by filtration, flocculation, ion exchange, or absorption. One shipyard employs sand filters and none use strainers or other prefiltering technologies. Filtering was more often used as a finishing step in the treatment train. Six of the shipyards are developing future containment and treatment strategies.

The next few paragraphs discuss treatment of hydroblast wastewater by various shipyards. Only one shipyard routes the water to a barge for oil/water separation to occur, and then discharges to the river. All the other shipyards use some combination of settling tanks and filtration, flocculation, or ion exchange.

The shipyard with the lowest cost of hydroblast management (<$.01/gal) has a unique system dedicated to hydroblast wastewater treatment that was designed in-house. The system is very simple, consisting of only a dirty water sump, a flocculation chemical tank, a pre-mix tank, a mixing tank, and a 2,000-gallon settling tank, from which the clean water is pumped to the sewer.

NASSCO, with the second lowest cost, purchased a turn-key system from Jalbert & Associates and it has worked quite well. The cost to treat water is $.04/gallon. The system consists of settling tanks, an oily water separator, and a dissolved air flotation unit to remove remaining metals and other solids.

One shipyard currently does not treat hull hydroblast wastewater, but does treat internal and open deck hydroblast wastewater. The shipyard typically provides two levels of pretreatment. The first level consists of settling in special tanks with a three-stage weir dam. The second level consists of flocculent additives to remove the solid metals. Under design is a two-tank system with a mounted 50 gpm pump with a filtration package that will allow recycling the water with zero discharge. This shipyard has investigated many treatment options with various vendors. Many of these tests proved the claims regarding various processes to be false under working conditions. For example, the shipyard investigated a new technology that used a clay base flocculent that completely encapsulated the suspended wastes. This would have allowed for the waste product to be treated as clean dirt and disposed of in a standard dump box at the same rate and risk as solid sanitary waste. This system was claimed capable of treating 10,000 gallons in 30 minutes. Then the liquid could have been reused as clean. The only waste generated would have been the solids generated by the flocculent at a rate of two pounds of waste per 10,000-gallon tank. The new technology failed during testing, and the shipyard is still assessing its treatment options. It is recommended that shipyards screen products by requiring demonstrations using the shipyards' wastewater at a pilot scale.

Another shipyard located in Florida is only required to collect hydroblast water containing organotin. It is collected in a tank where the water is evaporated. However, they pay to transport their other processed wastes to an outside industrial treatmeni plint.

Still another shipyard, under part per trillion discharge limit requirements, is experimenting with sand filters followed by resins to remove copper and tributyltin. However, this has been very expensive for them at $30/lb. for the resins. The shipyard does not segregate their hydroblast water from other waste streams, resulting in millions of gallons requiring treatment.

III.3 Shipyard Applicability

The ship repair industry generates hundreds of thousands of gallons of overboard and other process wastewater, and with the arrival of stricter regulations, shipyards have begun on-site wastewater treatment. As analytical detection limits get lower, municipalities are lowering their discharge limits. In addition, transportation and disposal companies are an expensive option. The survey shows that the trend for shipyards is to treat wastewater in-house to reduce costs, and several shipyards were observed treating wastewater. It is becoming more cost efficient for shipyards to perform wastewater treatment. It must be stated that the variable of cost of treatment depends on the treating technology used and how the wastewater is handled within the shipyard. Ultimately each shipyard must evaluate the individual needs in their area and evaluate the real treatment cost per gallon.

SECTION 4

VENDOR SURVEY RESULTS

4.1 Methodology

This section presents a summary of the information gathered from surveying 126 vendors. The objective of the vendor survey is to identify what currently available pretreatment technologies can be applied to hydroblast wastewater treatment. The survey mailing list was compiled from the 1993 Chemical Engineering Buyer's Guide, 1993 Pollution Equipment News Buyer's Guide, and the 1993 Pollution Engineering Buyer's Guide. Other buyer's guides that were not used, but are valuable references include the 1993-1994 Environmental Management Sourcebook and the 1993 Plant Engineering Product Supplier Guide. Subjects such as screens, filters, and wastewater treatment were researched and a survey was sent to all listed companies. It should be emphasized that there are far too many companies to include all of them in the survey. This shows the competitive nature of the wastewater treatment market. Surveys were mailed without prior telephone notification about the project, which may partially account for the low return. One hundred twenty-six surveys were mailed and 20 responses were received. Another eight surveys were returned in the mail due to a changed address. Table 4-1 lists the companies surveyed, and Table 42 shows vendor products. Appendix B contains the vendor survey.

4.2 Results

The wastewater treatment industry is very competitive and there are hundreds of companies offering many products for many applications. The method used for a particular application depends on the volumetric flow rate, physical characteristics, and concentrations of the influent and the cost-effectiveness of the method and equipment. Wastewater treatment methods are discussed in depth in Section 8.1.

Survey results are limited in interpretation by the nonuniformity of responses and the multitude of product types. For example, the responder varied from a Sales Representative to the Vice-President of Marketing, to the President of the company. Each responder's perspective is reflected in his answers, and creates variability in the emphasis and completeness of the answers. Further, the bias inherent in responses due to the responder's desire to position his product well with respect to other survey responses must be considered. As mentioned above, there are many technologies and companies around the country and the survey represents only a sampling of the wastewater treatment equipment suppliers and equipment currently on the market. It is difficult to draw conclusions from the results, and instead of a vendor survey result matrix, a vendor product matrix was prepared as Table 4-2.

COMPANIES SURVEYED	ADDRESS	CITY, STATE, ZIP	PHONE NO.	SURVEY SENT	SURVEY RESPONSE RECEIVED	RECEIVED BACK IN THE MAIL
ADVANCED RECOVERY TECHNOLOGIES CORP.	35103 MILE ROAD	WALKER, MI 49504	(619) 453-4630	YES	NO	YES
AEROMIX SYSTEMS, INC.	2611 N. 2ND STREET	MINNEAPOLIS, MN 55411	(612) 521-8519	YES	YES	
AFL INDUSTRIES	3661 W. BLUE HERON BLVD.	RIVIERA BEACH, FL 33404	(407) 844-5200	YES	NO	
ALAN COBHAM ENG. LTD.	HOLLAND WAY	BLANDFORD, DORSET, UK DT117BJ	(258) 451-441	YES	YES	
ALAR ENGINEERING CORP.	9651 W. 196TH STREET	MOKENA, IL 60448	(708) 479-6100	YES	NO	
ALLEN FILTERS, INC.	P.O. BOX 747	SPRINGFIELD, MO 65801	(417) 865-2844	YES	NO	
AMERICAN EQUIPMENT CO. OF WASHINGTON	4401 PACIFIC HIGHWAY E.	FIFE, WA 98424	NA	YES	NO	
AMETEC PLYMOUTH PROD. DIV.	502 INDIANA AVENUE	SHEBOYGEN, WI 53081	(414) 457-9435	YES	NO	
ANDCO ENVIRONMENTAL PROCESSES, INC.	595 COMMERCE DRIVE	AMHERST, NY 14228	(716) 691-2100	YES	NO	
ANDRITZ SPROUT BOUER, INC.	SHERMAN STREET	MUNCY, PA 17756	(717) 546-8211	YES	NO	
APPLIED MEMBRANES, INC.	110 BOSSTICK BLVD.	SAN MARCOS, CA 92069-5930	(619) 727-3711	YES	NO	
AQUACARE ENVIRONMENT, INC.	P.O. BOX 4315	BELLINGHAM, WA 98227	(206) 734-7964	YES	NO	
AQUA CRAFT	P.O. BOX 653	SAN CARLOW, CA 94074	(415) 637-0322	YES	NO	
AQUA CHEM, INC. WATER TECH.	P.O. BOX 421	MILWAUKEE, WI 53201	(414) 359-0600	YES	NO	
ASHBROOK SIMON HARTLEY CORP.	11600 E. HARDY	HOUSTON, TX 77093	(713) 449-0322	YES	NO	
ATKOMATIC VALVE CO.	141 S. SHEMAN DRIVE	INDIANAPOLIS, IN 46201	(317) 357-8421	YES	YES	
BACT ENGINEERING, INC.	11 W. COLLEGE DRIVE, SUITE K	ARLINGTON HEIGHTS, IL 60004	(708) 577-0950	YES	NO	
BALSTON, INC.	260 NECK ROAD, P.O. BOX 8223	HAVERVILL, MA 01835-0723	(508) 374-7400	YES	NO	
BLACE FILTRONICS, INC.	10914 N.E. 39TH STREET, SUITE B-2	VANCOUVER, WA 98662	NA	YES	NO	YES
CALGON CARBON CORP.	P.O. BOX 717	PITTSBURGH, PA 15230	(412) 787-6700	YES	NO	
CAMP CRESSER & McKEE, INC.	ONE CAMBRIDGE CENTER	CAMBRIDGE, MA 02142	(617) 621-8181	YES	NO	
CHEMETRICS	ROUTE 28	CALVERTON, VA 22016	(800) 356-3072	YES	NO	
COLLOID ENVIRONMENTAL TECH.	1500 W. SHURE DRIVE	ARLINGTON HEIGHTS, IL 60004	(708) 392-5800	YES	NO	
COLUMBIA PACIFIC AND ASSOC.	7451 S.W. COHO COURT, SUITE 103	TUALATIN, OR 97062	NA	YES	NO	YES
CONTAINMENT SYSTEMS	P.O. BOX 1390	COCOA, FL 32923	(407) 632-5640	YES	NO	
COOK SCREEN TECH., INC.	1292 GLENDALE MILFORD ROAD	CINCINNATI, OH 45215	(513) 771-9192	YES	NO	
CONTECH CONSTRUCTION PRODUCTS, INC.	1001 GROVE STREET	MIDDLETOWN, OH 45044	(513) 425-5896	YES	NO	
COSTAR CORP.	ONE ALEWIFE CENTER	CAMBRIDGE, MA 02140-2323	(617) 868-6200	YES	NO	
COUNTREY AND NYE	P.O. BOX 787	MILTON, WA 98050	NA	YES	NO	
CRANE CO. COCHRANE ENVIRONMENTAL SYSTEM	P.O. BOX 191	KING OF PRUSSIA, PA 19406-0191	(215) 265-5050	YES	NO	
CULLIGAN INTL. CO.	1 CULLIGAN PARKWAY	NORTHBROOK, IL 60062	(708) 205-6000	YES	NO	
DAVIS INDUSTRIAL WASTE SYS.	1828 METCALF AVENUE	THOMASVILLE, GA 31792	(912) 226-5733	YES	NO	
DELTA POLLUTION CONTROL, INC.	30540 S.E. 84TH STREET	PRESTON, WA 98050	NA	YES	YES	
DI SEP SYSTEMS	14040 SANTA FE TRAIL DRIVE	LENEXA, KS 66215	(913) 888-9089	YES	NO	
DYNAMIC PROCESS IND. CIV. FERGUSION IND.	1900 W. NORTHWEST HWY.	DALLAS, TX 75220	(214) 556-0010	YES	NO	
EDEN EQUIPMENT CO., INC.	17552 GRIFFIN	HUNTINGTON BEACH, CA 92647-6253	(714) 842-8181	YES	NO	
ELMCO PROCESS EQUIP. CO.	P.O. BOX 300	SALT LAKE CITY, UT 84110	(801) 526-2425	YES	NO	
EJECTOR SYSTEMS, INC.	910 NATIONAL AVENUE	ADDISON, IL 60101	(708) 543-2014	YES	NO	
EMCON	400 S. EL CAMINO REAL, SUITE 1200	SAN MATEO, CA 94402	(415) 375-1522	YES	NO	
EMISSIONS TECHNOLOGY, INC.	5092 STEADMONT	HOUSTON, TX 77040	(713) 448-0135	YES	NO	
ENSYS ENVIRONMENTAL PROD.	P.O. BOX 14063	RESEARCH TRIANGLE PARK, NC 27709	(919) 941-5509	YES	NO	
ENVIRO CARE CO.	5614 W. GRAND AVENUE	CHICAGO, IL 60639	(312) 745-7773	YES	YES	
ENVIRONMENTAL ASSOC., INC.	460 S.W. MADISON, SUITE 1	CORVALL, OR 97333	NA	YES	NO	
ENVIRONMENTAL SYSTEMS ENGINEERING	15455 RED HILL AVENUE	TUSTIN, CA 92680	(714) 259-1411	YES	NO	
EPOC WATER, INC.	3065 N. SUNNYSIDE	FRESNO, CA 93727-1344	(209) 291-8144	YES	YES	
FISCHER AND PORTER CO.	P.O. BOX 3355	WARMINSTER, PA 18974	(215) 674-6000	YES	NO	
FLUID COMPONENTS, INC.	1755 LA COSTA MEADOWS DRIVE	SAN MARCOS, CA 92069	(619) 744-6950	YES	NO	
FREE ROW, INC.	P.O. BOX 4067 BENSON STATION	OMAHA, NE 68104	(402) 397-8910	YES	YES	
GOMAN URPP CO.	305 BOWMAN STREET, BOX 1217	MANSFIELD, OH 44902	(419) 755-1011	YES	NO	
GREAT LAKES ENVIRO., INC.	463 VISTA	ADDISON, IL 60101	(708) 543-9444	YES	YES	
HARMSCO INDUSTRIAL FILTERS	P.O. BOX 14066	NORTH PALM BEACH, FL 33408	(407) 848-9628	YES	NO	
HAYWARD INDUSTRIAL STRAINER	900 FAIRMOUNT AVENUE	ELIZABETH, NJ 07207	(908) 351-5400	YES	NO	

Table 4-1(1): Vendor Survey Mailing List

COMPANIES SURVEYED	ADDRESS	CITY, STATE, ZIP	PHONE NO.	SURVEY SENT	SURVEY RESPONSE RECEIVED	RECEIVED BACK IN THE MAIL
HI TECH	P.O. BOX 360597	BIRMINGHAM, AL 35236	(205) 987-8976	YES	NO	
HYDROCAL, INC.	22732 GRANITE WAY #A	LAGUNA HILLS, CA 92653-1202	(714) 455-0765	YES	NO	
HYDROLLO TECHNOLOGIES, INC.	125 W. FAY AVENUE	ADDISON, IL 60101	(708) 543-8012	YES	NO	
HYDROLAB CORPORATION	P.O. BOX 50116	AUSTIN, TX 78763	(512) 255-8841	YES	YES	
IEECO	7622 146TH STREET, CT. E	PUYALLUP, WA 98373	NA	YES	NO	YES
INDEPENDENT EQUIP. CORP.	5 JOHNSON DR., P.O. BOX 130	HILLSBORO, OR 97123-1079	(503) 648-2014	YES	YES	
INSTRUMENTATION N.W., INC.	14972 N.E. 31ST STREET CIRCLE	RENMOND, WA 98052	(206) 885-3729	YES	NO	
INVALCO	P.O. BOX 1183	HUTCHINSON, KS 67504-1183	(316) 665-6667	YES	NO	
JALBERT	150 SOUTH MAIN STREET	NORFOLK, VA 23523	(804) 545-5555	YES	YES	
KASON CORP.	1301 E. LINDEN AVENUE	LINDEN, NJ 07036	(908) 486-8140	YES	NO	
KOMAX SYSTEMS, INC.	P.O. BOX 1323	WILMINGTON, CA 90748-1323	(310) 830-4320	YES	NO	
KOMLINE SANDERSON	HOLLAND AVENUE	PEAPACK, NJ 07977	(908) 234-1000	YES	NO	
KRYSTIL KLEAR DIV. GMB	RR #2, P.O. BOX 300	WINAMAC, IN 46996	(219) 278-7161	YES	NO	
LCI CORP. FLUID SYSTEMS	P.O. BOX 16348	CHARLOTTE, NC 28297-6348	(704) 394-8341	YES	NO	
MATT SON, INC.	28W005 INDUSTRIAL AVENUE	BARRINGTON, IL 60010	(708) 382-5814	YES	NO	
MEMTEK CORP.	28 COOK STREET	BELLERICA, MA 01821	(904) 822-8000	YES	NO	
MET-PRO CORP. SYSTEMS DIV.	160 CASSELL ROAD, P.O. BOX 144	HARLEYSVILLE, PA 19438	(215) 723-6751	YES	NO	
MIXING SYSTEMS, INC.	5355 FAR HILLS AVENUE	DAYTON, OH 45429-2313	(513) 435-7227	YES	NO	YES
MOBILE WATER TECHNOLOGY	2070 AIRWAYS BLVD.	MEMPHIS, TN 38114	(901) 744-1142	YES	NO	
MONOE ENVIRONMENTAL CORP.	11 PORT AVENUE, P.O. BOX 806	MONROE, MI 48161	(313) 242-7654	YES	NO	
NETZSCH, INC.	119 KICKERING WAY	EXTON, PA 19341	(215) 363-8010	YES	YES	
NORTON PERFORMANCE PLASTICS CORP.	150 DEY ROAD	WAYNE, NJ 07470	(201) 696-4700	YES	NO	
NORTHWEST FILTER CO.	345 UPLAND DRIVE	TUKWILA, WA 98188	NA	YES	NO	YES
OIL SKIMMERS, INC.	P.O. BOX 33092	CLEVELAND, OH 44133	(216) 237-4600	YES	NO	
OSMONICS, INC.	5951 CLEARWATER DRIVE	MINNETONKA, MN 55343	(612) 933-2277	YES	NO	
PACE INTERNATIONAL CORP.	3727 S. ROBERTSON BLVD.	CULVER CITY, CA 90232	(310) 839-1188	YES	NO	
PACIFIC PRESS	3720 PROSPECT	YORBA LINDA, CA 92622	(714) 524-8029	YES	NO	
PARKINSON CORP.	2727 N.W. 62ND ST., P.O. BOX 408399	FORT LAUDERDALE, FL 33340	(305) 974-6610	YES	NO	
PENGUIN PUMP FILTER PUMP IND. DIV.	7932 AJAY DRIVE	SUN VALLEY, CA 91352	(818) 504-2391	YES	NO	
PERMUTT CO. INC. DIVISION OF ZUM IND. INC.	30 TECHNOLOGY DRIVE	WARRENS, NJ 07059-0920	(908) 668-1700	YES	NO	
PERRIN GILLIAM R CO. LTD.	432 MONARCH AVENUE	AJAX, ORT, CANADA, L1S 2G7	(416) 683-9400	YES	NO	
PLAST O MATIC MVALVES, INC.	430 ROUTE 46	TOTOWA, NJ 97512	(201) 256-3000	YES	NO	
PLASTIC ENGINEERED PRODUCTS, INC. (PEPCO)	50 TANNERY ROAD, UNIT 3	BRANCHBURG, NJ 08876	(908) 534-6111	YES	YES	
POLLUTION CONTROL ENG., INC.	3233 HALLADAY STREET	SANTA ANA, CA 92705	(714) 641-1401	YES	NO	
POLLUTION EQUIPMENT CO.	220-B OLD DARY ROAD	WILMINGTON, NC 28405	(919) 452-5663	YES	NO	
POLLUTION CONTROL LAB.	960 REMILLARD COURT	SAN JOSE, CA 95122	(408) 294-8694	YES	NO	
PORETICS CORP.	111 LINDBERG AVENUE	LIVEMORE, CA 94550	(510) 373-0500	YES	NO	
PROCESS EFFICIENCY PRODUCTS, INC.	20850 DEARBORN STREET	CHATSWORTH, CA 91311-4320	(818) 772-7795	YES	NO	
PURESTREAM, INC.	P.O. BOX 68	FLORENCE, KY 41042	(606) 371-3577	YES	NO	
QED ENVIRONMENTAL SYS., INC.	P.O. BOX 3726	ANN ARBOR, MI 48106	(800) 624-2026	YES	NO	
QUANTUM ANALYTICS	363-D VINTAGE PARK DRIVE	FOSTER CITY, CA 94404	(415) 570-5656	YES	NO	
RECON SYSTEMS, INC.	5 JOHNSON DR., P.O. BOX 130	RARITAN, NJ 08869-0130	(908) 526-1000	YES	NO	
RESOURCES CONSERVATION CO.	3006 NORTHUP WAY	BELLEVUE, WA 98004-1445	(206) 828-2400	YES	YES	
ROBERTS FILTER MANUFACTURING CO	214 N.E. 83RD STREET	VANCOUVER, WA 98665	(206) 573-7176	YES	NO	
ROSEDALE PRODUCTS, INC.	P.O. BOX 1085	ANN ARBOR, MI 48106	(313) 665-8201	YES	NO	
ROTEX, INC.	1230 KNOWLTON STREET	CINCINNATI, OH 45223	(513) 541-1236	YES	NO	
SCHREIBER	100 SCHREIBER DRIVE	TRUSSVILLE, AL 35173	(205) 655-7466	YES	NO	
SCIENCO/FAST SYSTEMS	3240 N. BROADWAY	ST. LOUIS, MO 63147	(314) 621-2536	YES	YES	
SERCK BAKER, INC.	15142 ELECTRONIC DRIVE	HUNTINGTON BEACH, CA 92649-1334	(714) 898-3474	YES	NO	
SERFILCO LTD.	1777 SHERMER ROAD	NORTHBROOK, IL 60062	(708) 559-1777	YES	NO	
SIMONS WTS, INC.	276 MARTIN AVENUE	SANTA CLARA, CA 95050	(513) 792-2300	YES	NO	YES
STAR SYSTEMS FILTRATION DIV.	101 KERSHAW STREET	TIMMONSVILLE, SC 29161	(803) 346-3101	YES	NO	
TECHNOTREAT CORP.	6216 S. LEWIS	TULSA, OK 74136	(918) 742-5052	YES	NO	
TENCO HYDRO, INC.	4620 FOREST AVENUE	BROOKFIELD, IL 60513	(708) 387-0770	YES	NO	

Table 4-1(2): Vendor Survey Mailing List (Cont.)

COMPANIES SURVEYED	ADDRESS	CITY, STATE, ZIP	PHONE NO.	SURVEY SENT	SURVEY RESPONSE RECEIVED	RECEIVED BACK IN THE MAIL
TETKO. INC.	333 S. HIGHLAND AVENUE	BRIARCLIFF MANOR. NY 10510	(914) 941-7767	YES	NO	
THAMES TECHNOLOGY, INC.	849E. DALLAS STREET	GRAPEVINE.TX 76051	[817)329-8360	YES	NO	YES
THROOP GEORGE L CO.	P.O. BOX 92405	PASADENA CA 91109-2405	[818) 769-0285	YES	NO	
TIGG CORP..	P.O.BOX 11661	PITTS BURGH. PA 15223	(412) 563-4300	YES	YES	
TREATMENT TECHNOLOGIES	P.O. BOX 730 POPULAR ROAD	HONEYBROOK. PA 19344-0730	(215) 273-2799	YES	YES	
UNITED STATES FILTER CORP.	12442 E. PUTTMAN STREET	WHIITLER. CA 90602	(310) 698-9414	YES	NO	
UNITEO STATES FILTER CORP. LANCY SYSTEMS	181 THOM HILL ROAD	WARRENDALE. PA 15086-00443	(412)772-0044	YES	NO	
UNOCAL UNIPURE	1511 E. ORANGETHORPE	FULLERTON.CA 92631	(714)525-9225	YES	NO	
UNIVERSAL PROCESS EOUIP.	P.O. BOX 338	ROOSEVELT. NJ 08555	(609)4434545	YES	NO	
UNITED SENSORS	38 C. OTIS STREET	WEST BABYLON. NY 11704	(516) 253-0500	YES	NO	
VULCAN IRONWORK, INC.	8-18 W. MARKET ST.,MELLON BAR	WILKES BARRE. PA 18711	(717) 822-3568	YES	NO	
WASTATES CORBON, INC.	2133 LEO AVENUE	LOS ANGELES. CA 90040	(213) 722-7500	YES	NO	
WESTECH ENGINEERING	P.O.B0x65068	SALET LAKE CITY. UT 84115	(801) 265-1000	YES	YES	
WESTERN FILETER CO.	P.O. Box 16323	OENVER CO 80216-0323	(303) 288-2617	YES	NO	
WILDEN PUMP AND ENGINEERING COMPANY	22069 VAN VUREN STSREET	COLTON. CA 92324	(714)422-1700	YES	NO	
WIESMANN ENGINEERING INC.	P.O.BOX 10037	LARGO, FL 35643	(813)535-4495	YES	NO	
YOUNG INDUSTRIES, INC.	PAINTER STREET,P.O. BOX 30	MUNCY. PA 17756	(717)546-3165	YES	NO	
ZEMARC CORP.	224 G4SPAR AVENUE	LOS ANGELES. CA 90040	(213)721-5598	YES	YES	
ZENON WATER SYSTEMS. INC.	845 BARRINGTON CT.	BURLINGTON. ONT. CANADA.L7N3P3	(416) 639-6320	YES	NO	
ZIMPRO PASSAVANT	301 MILITARY ROAD	ROTHSCHILD. WI 54474	(715) 359-7211	YES	YES	

Table 4-1(3): Vendor Survey Mailing List (Cont.)

Until the mid-1970s, many companies were oriented toward municipal wastewater treatment. It is important to learn from the vendor if the equipment is designed for or can be applied to industrial wastewater treatment. Due to the vast amount of products on the market, it is critical for the engineer to be completely aware of the applications, characteristics, and constraints. Another obvious but important conclusion is that there are no companies specializing in containment systems for dry docks; these must either be engineered in-house or subcontracted to a construction company. Some companies offer containment system components such as submersible pumps, level sensors, and storm water diversion devices. Finally companies are emerging which offer products specifically designed for shipyard hull wash water, such as Delta Pollution Control.

COMPANY NAME	PRIMARY TECHNOLOGY	DAF	DEWATERING	FILTER HOLDERS/HOUSINGS	FILTERS, LIQUID	FILTER MEDIA, LIQUID	FILTER PRESSES	FILTRATION SYSTEMS	MONITORING EQUIPMENT AND INSTRUMENTS
ADVANCED RECOVERY TECHNOLOGIES CORP.	CARBON ABSORBTION				•	•		•	
AEROMIX SYSTEMS, INC.	MIXERS								
AFL INDUSTRIES	OIL/WATER SEPARATORS		•			•		•	
ALAN COBHAM ENG. LTD.	FILTRATION								
ALAR ENGINEERING CORP.	NA	•	•		•	•		•	
ALLEN FILTERS, INC.	NA								
ALSOP ENGINEERING CO.	NA								
AMETEC PLYMOUTH PROD. DIV.	FILTRATION				•				
ANDCO ENVIRONMENTAL PROCESSES, INC.	WW TREATMENT SYSTEMS		•			•			
ANDRITZ SPROUT BOUER, INC.	HYDROSIEVE		•		•				
APPLIED MEMBRANES, INC.	CLEAN WATER SYSTEMS			•	•			•	
AQUACARE ENVIRONMENT, INC.	FILTRATION				•			•	
AQUA CRAFT	NA				•	•		•	
AQUA CHEM, INC. WATER TECH.	WW TREATMENT SYSTEMS								
ASHBROOK SIMON HARTLEY CORP.	DEWATERING		•		•				
ATKOMATIC VALVE CO.	VALVES								
BACT ENGINEERING, INC.	NA				•	•		•	
BALSTON, INC.	NA					•		•	
CALGON CARBON CORP.	NA								
CAMP CRESSER & McKEE, INC.	NA								
CONTAINMENT SYSTEMS	NA								
COOK SCREEN TECH., INC.	SCREENS/STRAINERS								
CONTECH CONSTRUCTION PRODUCTS, INC.	COLLECTOR PANS								
COSTAR CORP.	FILTRATION				•	•		•	
CRANE CO. COCHRANE ENVIRONMENTAL SYSTEM	WW TREATMENT SYSTEMS				•			•	
CULLIGAN INTL. CO.	MUNICIPAL ONLY								

Table 4-2 (1): Vendor Products

COMPANY NAME	PRIMARY TECHNOLOGY	DAF	DEWATERING	FILTER HOLDERS/HOUSINGS	FILTERS, LIQUID	FILTER MEDIA, LIQUID	FILTER PRESSES	FILTRATION SYSTEMS	MONITORING EQUIPMENT AND INSTRUMENTS
DISEP SYSTEMS	REVERSE OSMOSIS							•	
DYNAMIC PROCESS IND. CIV. FERGUSION IND.	GW REMEDIATION								
EDEN EQUIPMENT CO., INC.	FILTRATION SYSTEMS							•	
ELMCO PROCESS EQUIP. CO.	NA	•	•		•	•	•	•	
EJECTOR SYSTEMS, INC.	AIR STRIPPERS								
EMCON	NA								
EMISSIONS TECHNOLOGY, INC.	NA	•						•	
ENVIRO CARE CO.	SCREENS								
ENVIRONMENTAL SYSTEMS ENGINEERING	NA		•			•		•	
FLUID COMPONENTS, INC.	MONITORS								•
FREE ROW, INC.	FLOW MEASUREMENT								
GOMAN RUPP CO.	PUMPS		•						
GREAT LAKES ENVIRO., INC.	WW TREATMENT SYSTEMS	•			•			•	
HARMSCO INDUSTRIAL FILTERS	LIQUID FILTERS				•				
HAYWARD INDUSTRIAL STRAINER	FILTRATION							•	
HI TECH	NA	•			•				
HYDROCAL, INC.	FLOTATION SYSTEMS								
HYDROFLO TECHNOLOGIES, INC.	NA							•	
HYDROLAB CORPORATION	MONITORING EQUIPMENT								•
INSTRUMENTATION NORTHWEST, INC.	GW MONITORING				•				•
INVALCO	WATER QUALITY INSTRUMENTS								•
KASON CORP.	SCREENS/STRAINERS								
KOMLINE SANDERSON	NA	•	•		•		•	•	
KRYSTIL KLEAR DIV. GMB	FILTRATION			•	•	•		•	
LCI CORP. FLUID SYSTEMS	SOLVENT RECOVERY								
MATT SON, INC.	FILTRATION			•		•		•	

Table 4-2 (2): Continued

COMPANY NAME	PRIMARY TECHNOLOGY	DAF	DEWATERING	FILTER HOLDERS/HOUSINGS	FILTERS, LIQUID	FILTER MEDIA, LIQUID	FILTER PRESSES	FILTRATION SYSTEMS	MONITORING EQUIPMENT AND INSTRUMENTS
MEMTEK CORP.	WW RECYCLING EQUIPMENT								
MOBILE WATER TECHNOLOGY	WW TREATMENT EQUIPMENT				•	•		•	
MONROE ENVIRONMENTAL CORP.	OIL/WATER SEPARATION				•			•	
NETZSCH, INC.	FILTRATION		•		•			•	
NORTON PERFORMANCE PLASTICS CORP.	GW MONITORING								
OIL SKIMMERS, INC.	OIL/WATER SEPARATION							•	
OSMONICS, INC.	FILTRATION			•	•	•		•	
PACE INTERNATIONAL CORP.	WW RECYCLING EQUIPMENT								
PACIFIC PRESS	FILTER PRESSES		•				•		
PARKINSON CORP.	NA		•		•		•	•	
PENGUIN PUMP FILTER PUMP IND. DIV.	FILTRATION							•	
PERMUTT CO. INC. DIVISION OF ZUM IND. INC.	WW TREATMENT SYSTEMS	•			•	•		•	
PERRIN WILLIAM R CO. LTD.	NA		•		•		•	•	
PLAST O MATIC MVALVES, INC.	VALVES							•	
PLASTIC ENGINEERED PRODUCTS, INC.	PLASTIC PRODUCTS								
POLLUTION CONTROL ENG., INC.	WW TREATMENT SYSTEMS	•	•		•			•	
POLLUTION EQUIPMENT CO.	GW REMEDIATION EQUIPMENT								
POLLUTION CONTROL LAB.	WW TREATMENT EQUIPMENT								
PORETICS CORP.	LIQUID FILTERS				•				
QED ENVIRONMENTAL SYS., INC.	GW				•				
QUANTUM ANALYTICS	MONITORING EQUIPMENT								•
ROBERTS FILTER MANUFACTURING CO.	WW TRATMENT PLANTS								
ROSEDALE PRODUCTS, INC.	FILTRATION			•	•	•		•	
ROTEX, INC.	SCREENS/STRAINERS								
SCHREIBER	NA								
SCIENCO/FAST SYSTEMS	NA							•	

Table 4-2 (3): Continued

COMPANY NAME	PRIMARY TECHNOLOGY	DAF	DEWATERING	FILTER HOLDERS/HOUSINGS	FILTERS, LIQUID	FILTER MEDIA, LIQUID	FILTER PRESSES	FILTRATION SYSTEMS	MONITORING EQUIPMENT AND INSTRUMENTS
SERCK BAKER, INC.	NA		•					•	
SERFILCO LTD.	FILTRATION		•	•	•	•	•	•	
SIMONS WTS, INC.	WW TREATMENT SYSTEMS								
STAR SYSTEMS FILTRATION DIV.	FILTRATION		•		•	•	•	•	
TECHNOTREAT CORP.	EVAPORATORS								
TENCO HYDRO, INC.	WW TREATMENT SYSTEMS	•							
TETKO, INC.	FILTRATION				•				
THAMES TECHNOLOGY, INC.	FILTRATION				•		•		
THROOP GEORGE L CO.	FILTER MEDIA					•			
TIGG CORP.	AIR AND WATER TREATMENT				•	•		•	
TREATMENT TECHNOLOGIES	NA				•			•	
UNITED STATES FILTER CORP.	WW TREATMENT EQUIPMENT								
UNITED STATES FILTER CORP. LANCY SYSTEMS	WW TREATMENT EQUIPMENT								
UNOCAL UNIPURE	WW TREATMENT SYSTEMS								
UNIVERSAL PROCESS EQUIP.	NA		•		•				
UNITED SENSORS	SENSORS								
VULCAN IRONWORKS, INC.	INCINERATION		•						
WASTATES CORBON, INC.	CARBON ABSORBTION					•		•	
WESTECH ENGINEERING	CLARIFIERS	•			•			•	
WESTERN FILTER CO.	FILTRATION				•	•		•	
WILDEN PUMP AND ENGINEERING CO.	PUMPS								
WIESEMANN ENGINEERING, INC.	SCREENS/STRAINERS								
YOUNG INDUSTRIES, INC.	WW TREATMENT PLANTS								
ZEMARC CORP.	FILTRATION							•	

NOTES: NA = NOT AVAILABLE; WW = WASTEWATER
CLARIFIERS AND ION EXCHANGERS ARE NOT INCLUDED IN THE VENDOR SURVEY
THE TERM "PACKAGED WW TREATMENT PLANTS" IS FROM THE 1993 POLLUTION EQUIPMENT NEWS BUYER'S GUIDE.
THE GUIDE DID NOT DEFINE ITS PRODUCT CATEGORIES.

Table 4-2 (4): Continued

SECTION 5

HYDROBLAST WASTEWATER CHARACTERIZATION

5.1 Introduction

The goal of characterization is to identify hydroblast run-off contaminants in terms of source, size, and impact on discharge water quality to meet the requirements of wastewater control authorities. While the ultimate goal of any wastewater treatment system is to comply with regulations cost-effectively, achieving intermediate goals is implied. Analyses should be selected to assess treatability options. The best starting point for this is the process from which the contaminants originate. The options for treatment are closely linked to the idiosyncrasies of operational processes. It is important to decide whether the discharge is continuous or intermittent and whether there are any secondary constituents present that may inhibit a potential treatment technology.

Dry dock operations are by nature unsteady and the presence of secondary contaminants is highly proportional to waste segregation practices. It is not enough to analyze only for target compounds that are regulated, but also secondary unregulated contaminants that may interfere with the treatment process and constrain selection of the treatment method. Another benefit of analyzing the process is assessment of the potential for modifying the process to reduce, eliminate, or modify the contaminants of concern. Finally, wastewater characterization in terms of flow rates and patterns of flow to wastewater treatment operations is critical.

5.2 Selection of the Prototype Shipyard

Requirements for the selection of the prototype shipyard are

1. The prototype shipyard must perform hydroblasting

2. The prototype shipyard must be under discharge limits that require treatment of the wastewater before discharge

3. The prototype shipyard should have dry dock facilities that represent facilities at other shipyards, such as floating dry docks, ways, and graving docks.

NASSCO was selected as the prototype shipyard because, beyond meeting the above requirements, shipyards in other states often must comply with the regulations California shipyards are dealing with already. For example, the San Diego Bay is a “no discharge bay” and NASSCO has observed the new emphasis on receiving water quality by the EPA. Shipyards in California are required to manage storm water and process run-off water more proactively than shipyards

in other states. Regulations tend to migrate from California eastward, and where there is a concentration of shipyards, those shipyards are more highly regulated. In Virginia, for example, where there are several shipyards, the receiving water limits for certain contaminants are in the part per billion range.

Another reason for selecting NASSCO is that NASSCO hydroblasts both repair and new construction ships. Further, both NASSCO and NASSCO's neighbor, Southwest Marine, which is a repair yard, hydroblast Navy and commercial ships. Finally, the budget constraints of the project were such that extensive travel was not feasible.

5.3 Sources of Contaminants

5.3.1 Process Constraints

Because hydroblast water ricochets off the hull at high velocities, complete containment is difficult. NASSCO has not yet found a cost-effective way to contain hydroblast wastewater, so it falls to the dock floor and becomes mixed with other run-off contaminants. The only existing technology that precludes this problem is a closed loop recycling system, which is very expensive. Shipyard operations make it unavoidable for a variety of wastes to fall to the floor. As concluded in the 1979 EPA guidance document, the application of BMPs makes no quantitative difference in drainage water quality, although the report does assert that segregation and removal of debris are the most practical methods for reducing discharge of solids and wastewater. Further, the unsteady nature of dry dock operations, the different paint systems of Navy and commercial ships, and the variability introduced by subcontractors makes one universal characterization for all hydroblast wastewater unfeasible.

Each shipyard should conduct its own characterization of wastewater generated during the hydroblast operations. A simple approach to beginning a wastewater characterization is to collect two samples of each wastewater type. This method enhances the representativeness of the study, although it is still not enough for the sample to be statistically significant. For this study samples were collected from two Navy ships and two commercial ships. Commercial ships are more likely to have a variety of paint systems, whereas concentrations of contaminants in hydroblast wastewater from Navy ships will be fairly consistent from ship to ship since the paint system is often the same. Clearly, there is much more that can be done in characterizing hydroblast wastewater. In conclusion, the constraints of production are such that the relevant analysis for treatability is runoff wastewater, and this project included preliminary characterization of both hydroblast wastewater and runoff water for the prototype shipyard.

5.3.2 Discussion of Sources

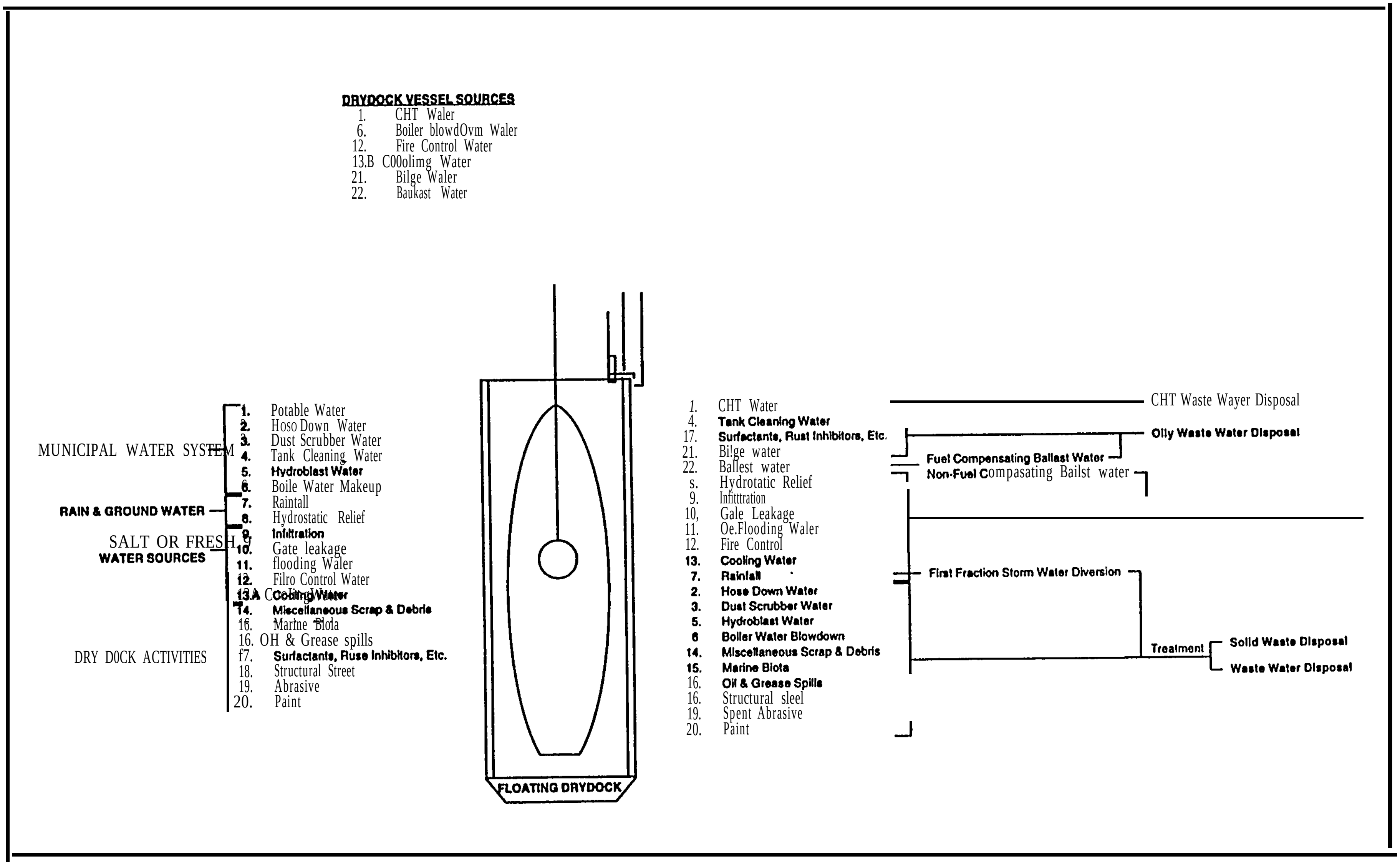
The best way to develop a complete characterization of a waste stream is by

performing a mass balance. Due to the broad range and variable nature of dry dock waste generation and multiple discharge pathways, this is extremely difficult. Repair operations in the dry dock encompass many activities and processes. Since they are not the same for every vessel, a typical process in a floating dry dock will be described. A floating dry dock was selected for description since it presents the most challenging containment and segregation problems.

A material balance has been prepared for the prototype shipyard's dry dock operations showing sources and fates of waste streams. (See Figure 5-l). The five effluent waste streams are the best practical achievable segregation and fates of the waste streams. The following description is chronological beginning with a clean deck and drydocking a vessel in a floating dry dock. Between every vessel, the dry dock floor is swept and hosed as clean as possible.

The first steps after raising the dock are to attach scupper hoses to the vessel for deballasting and removing bilge water, and to fresh water wash the hull. Other scupper hoses carry boiler blowdown, noncontact cooling water, and collection/holding/transfer (CHT) water from the vessel. CHT water discharges to the sewer, boiler blowdown to a wastewater treatment system, and noncontact cooling water to the receiving water. This is usually followed by scamping the marine growth, and the scampers are followed by hydroblasters. The marine growth falls to the dock floor and is swept up immediately and placed in designated skip tubs. Hydroblast wastewater containing rust inhibitor, abraded paint, and residual marine growth falls to the floor. As the wastewater runs off, some solid paint and marine growth settles on the dock floor. Sometimes, after hydroblasting is completed, the fuel, bilge, and ballast tanks are steam cleaned and then abrasive blasted. Any emulsified wash water containing fuel/oil and detergents is pumped through scupper hoses to holding tanks and then pumped to either a tank truck or a barge or treatment facility. The blast media is transported to storage facilities to await shipment to a recycle facility or a landfill. Often, hull abrasive blasting occurs simultaneously with interior tank abrasive blasting. These operations are followed by painting the hull. Containment methods include containment curtains on both forward and aft ends of the dock. The deck is cleaned daily of solid debris to simplify segregation. Small amounts of fresh and spent grit; fresh and spent paint, oil, grease, and fuel; and tank cleaning water may be spilled or leaked onto the deck during the above processes.

Sources of contaminants in runoff wastewater depend on origin, flow rate patterns, chemistry, and mechanics as the water runs off the dock. As discussed above, besides the primary sources of contaminants to run-off, small amounts of miscellaneous wastes are part of runoff water. The two waste streams that primarily make up runoff water are hydroblast wastewater and storm water. The primary sources of contaminants to hydroblast wastewater are, as observed in the shipyard survey, spent paint, spent grit, marine growth, and rust inhibitor. Oil, grease, fuels, and detergents are suspected to be present in small quantities from spills and leaks. Visually, hydroblast wastewater appears from clear with



f/gure 5-1: Sourcos and Fates of Waste Streams in Dry Docks

large paint chips to deep reddish with paint sludge settled in the bottom. Sump water appears dark brown with some white flakes floating on the top. When a water sample was collected from the sump, it contained a fair amount of solids consisting mostly of abrasive blast media, with some filament shaped marine growth, algae, human hair, and trash.

5.4 Sampling Methodology

5.4.1 Sample Collection

A reproducible sampling method is required for two reasons. First, sampling events vary widely in layout and hydroblasting operational methods, and second, to reduce variability in analytical results due to the sampling method. The best sampling strategy for hydroblast wastewater is the one in the master's thesis by Kenneth Alexander (See Section 2.5.2). His strategy was generally incorporated into the sampling plan discussed below.

Sampling occurred from August 1993 to January 1994. A total of three hydroblast wastewater samples, six tank wastewater samples, and two sump runoff water samples were collected from five vessels. One barnacle sample and one sump solid sample were collected.

It is important to obtain a characterization that represents the entire hydroblasting operation, so the hull was divided into 12 zones and attempts were made to sample from several zones. Samples were collected in 10-gallon Tupperware storage totes with dimensions 24" x 16" x 8". One or two totes were placed in one of the zones. If two totes were in the same sample zone, a composite sample was made in the field by the following three-step process: first, agitating the tote to preserve the suspension of particles in the sample so that a representative sample would be collected; second, quickly decanting the water from one tote to fill half the sample bottle; and third, agitating and filling the rest of the bottle from the second tote. There was never more than one operator per zone, so risk of sample misidentification was reduced.

Efforts were made to ensure that hydroblasting methods were not altered by the presence of sampling, taking precautions to avoid prolonged blasting in any given area to collect the sample. This preserved the integrity of the sample. The sampling trays were moved to follow the operator's path and placed to collect the maximum amount of water in a given zone.

Two liters of sample were required for analysis according to the analytical strategy. After enough water was collected for one zone sample, the water was transferred according to the procedure described above to one liter amber glass bottles, capped, and labeled to describe the sample's origin. Each sample was labeled with the following information zone number, date, time, sampler's initials, and project name. Sample labels were written in waterproof ink and

affixed to the sample with clear tape to prevent contact with water. The tupperware containers were then washed with a two-step rinse: 1) tap water, and 2) deionized water, after each sample was collected.

One sample of the wash water was collected directly from the hydroblast nozzle for separate laboratory analysis for each ship. After labeling and logging, the sample bottles were placed in a 4-degree Celsius insulated cooler located on the floating dry dock. Upon arrival at the laboratory, the samples were transferred to the laboratory's refrigerated sample storage room.

Attempts were made to collect the following information at/for each sampling event:

1. Name and type of vessel
2. Hull material
3. Approximate time hydroblasting began and ended
4. Number of nozzles, nozzle volumetric flow rate, and pressure used
5. Approximate square footage blasted
6. The type of paint used in the last coat.

5.4.2 Quality Assurance (QA)/Quality Control (QC) Procedures

QA/QC procedures were set up in the field to reduce the potential for cross-contamination. These procedures were designed to ensure sample collection and maintenance would produce analytical results that were as accurate and representative as possible. Chain of custody and record keeping procedures were carried out during sampling activities. To prevent sample misidentification, each sample was labeled according to the procedures discussed in section 5.4.1. The samples, which were delivered to Analytical Chemists, Inc., in San Diego, California, on the same day as collected, were received by Aalytical Chemists, Inc. personnel. The samples were stored in a 4-degree refrigerator for preservation.

Laboratory personnel receiving the samples verified that all samples on the accompanying chain of custody were present. The person relinquishing and receiving the samples signed the chain of custody form, noting the date and time of the sample transfer on the form. All chains of custody were maintained in the project files.

5.5 Analytical Strategy

Samples were analyzed for the potential chemical constituents identified in Table 5-1. The analytical strategy developed is shown in Figure 5-2 and is similar to the analytical strategy in Kenneth Alexander's thesis. The strategy is oriented toward the primary determinants of the treatment technology that are chemical contaminants of concern and the size of particulate debris. Particle size is important because with large enough particles, gravitational settling may be the only

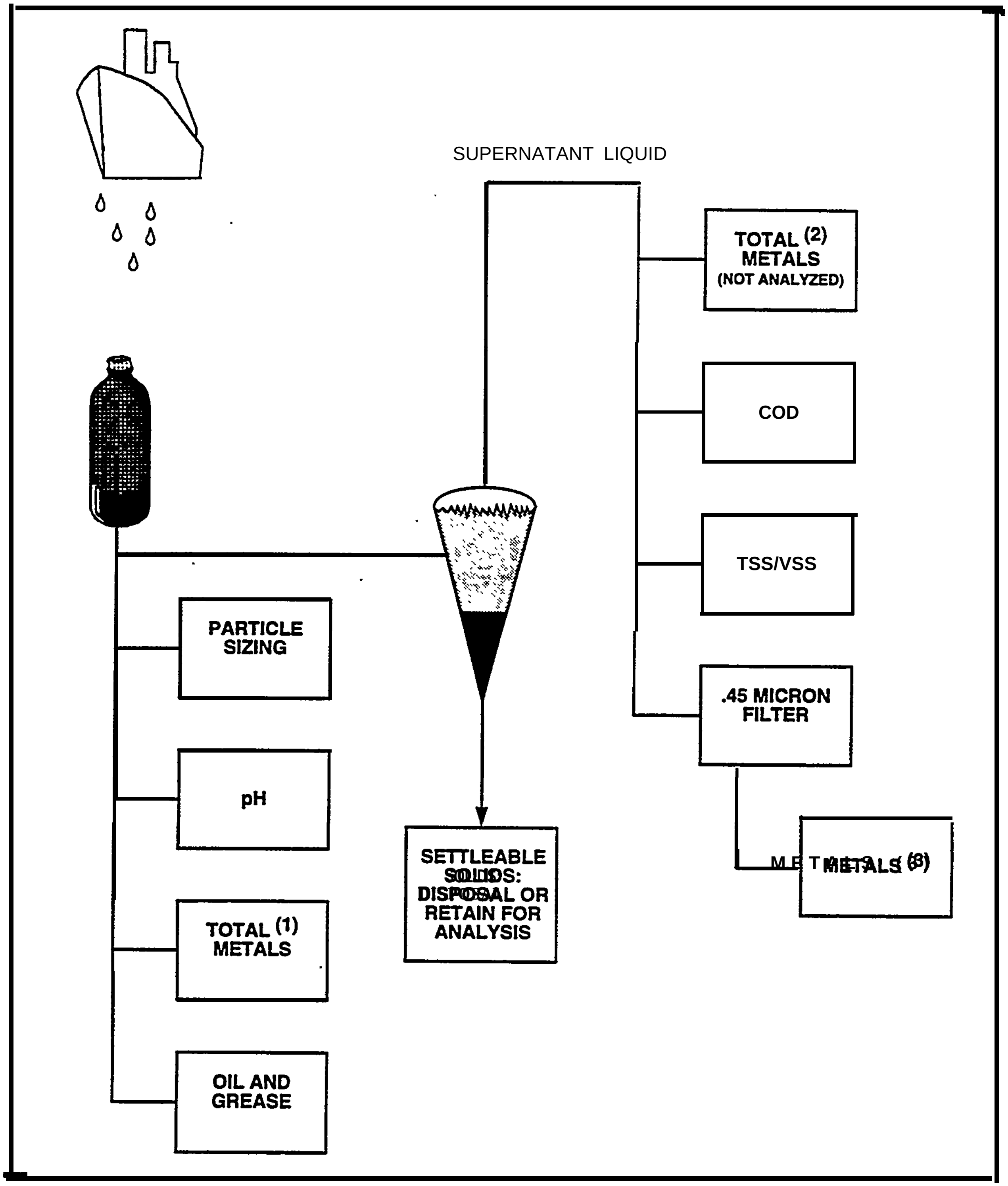
required treatment. However, there is a tradeoff between equipment costs and holding costs since settling can take up to two days. Nonspecific parameters such as pH, chemical oxygen demand (COD), and total suspended solids (TSS) are important to select treatability requirements. For example, a common method of metal removal is pH adjustment to optimize metal precipitation. COD is a relative measure of any matter in wastewater that will consume oxygen. COD is often used as an alternative to the 5-day BOD test used in municipal water treatment facilities. Organics in runoff water include toxic organic compounds, marine growth, and algae. Suspended solids are those particles that are too light to settle and too heavy to float. They are important because they are generally more difficult to remove by physical treatment such as settling and" often require advanced treatment techniques.

WASTE STREAM	CHEMICAL CONSTITUENTS	ANALYTICAL CATEGORY
SPENT PAINT	COPPER, TIN, ZINC, NICKEL, LEAD, CHROMIUM, CADMIUM ARSENIC, IRON, ALUMINUM, RESIN, EPOXY, POLYMERS	METAALS, ORGANIC
SPENT ABRASIVE	COPPER	METALS
MARINE BIOTA	NONE	METALS
HYDROBLAST WATER (PRIOR TO BLASTING)	TRACE METALS	NONE
OIL AND GREASE SPILLS	OIL AND GREASE	OIL AND GREASE
STRUCTURAL STEEL	IRON, MANGANESE	METALS
RUST INHIBITOR	SODIUM NITRATE, DIAMMONIUM PHOSPHATE	NONE

Table 5-1: Potential Chemical Contaminants in Run-off Wastewater

The primary contaminants of concern are the metals, especially copper, tin, lead, and zinc because of toxicity or quantity. Copper and tin are the toxic components in antifoulant paints, whereas zinc is the primary component of primer. Some paints (older ships and military vehicles) contain lead; lead is considered very toxic and is highly regulated. Copper and zinc are present in grit blast medium. Iron was included because one might expect rust to become part of the hydroblast wastewater. The other metals analyzed could be expected in trace amounts for various reasons.

Since metals are the main contaminants of interest, composite samples were analyzed for total metals (suspended, settleable, and dissolved), settleable metals, and dissolved metals. Samples were analyzed using Methods for the Chemical Analysis of Water and Waste, E.P.A. 600/4-79-020. Total metals analysis was performed on the raw sample by digestion (method 200.0) followed by atomic absorption (AA). Analysis for oil and grease was performed on the raw sample by solvent extraction and then gravimetry. Settleable solids were measured volumetrically after settling for 30 minutes in an Imhoff cone. The supernatant liquid was used to determine COD, TSS, and dissolved metals analyses. COD



NOTES:
(1)' Metals = Suspended, settleable plus dissolved
(2) Metals. Suspendad plus dissolved
(3) Metals = Dissolved (solub!e)

Figure 5-2: Analytical Strategy

analysis was accomplished by digestion followed by calorimetry. Total Suspended Solids (TSS) were analyzed by filtration followed by gravimetry. Dissolved metals analysis was done by filtering the supermatant through a .45 micron filter, digestion, and analysis by atomic absorption.

Quality control procedures in the laboratory involved spiking one of the samples from each sampling event in duplicate prior to digestion and analysis. The percent recovery and relative percent difference (RPD) from the spike procedure provide the statistics. Although 0-30% RPD and 75-125% recovery are the laboratory's acceptance criteria, non-homogeneity in the samples mitigates these values.

5.6 Analytical Results and Interpretation

This section presents a summary of the analytical results of the Phase I sampling program. Results of analyses are presented in Table 5-2. Results are discussed with respect to the antifoulant paint system blasted off the hull, the pathway of runoff water from the hull to storage tanks, NASSCO's sewer discharge limits, shipyard survey participants' sewer limits, and the contaminant's effect on treatment requirements. Finally, the analytical results are compared to the characterization results of three other studies.

The samples were expected to contain copper and tin from antifoulant as well as other paint contaminants such as zinc, lead, and organic compounds. The antifoulant paint on the HERACLES SPIRIT, USNS SPICA, and USS CHANCELLORSVILLE was copper based, and the antifoulannt paint on FAIR PRINCESS and VIKING SERENADE was tributyltin based. Copper was present in samples from all five vessels. Of the three ships with a copper based antifoulant, SPICA and CHANCELLORSVILLE hull samples exhibited high (average of 42 ppm) and similar amounts of copper. A hull sample was not collected from HERACLES SPIRIT.

Tin was not present at the detection limit of three ppm in samples from the two ships that had tributyltin based antifoulant paint. However, there was significant copper in the wastewater from the ships with tributyltin based antifoulants. The source of the copper is most likely from a previous paint system or suspended copper grit particles since on inspection, VIKING SERENADE sump sample's settleable solids contained several grit particles. Of the three ships with copper based antifoulant paint, tin was not analyzed for HERACLES SPIRIT and SPICA; CHANCELLORSVILLE's sump sample contained 2.2 ppm tin. The source of the tin is unknown. Zinc is present in significant quantities in all the wastewater samples, while lead was not detected in any of the samples except for SPICA's Baker Tank No. 2 sample, which contained .54 ppm lead. The organic contaminants contributed to the COD results, which indicated some organic material was present in the wastewater.

NSRP WATER FIl TRATI0N STUDY PHASE I

SAMPLE	SHIP	SAMPLE	LAB ID NO.	WET OR DRY WT	PARAMETERS AND METHODS																				
					Ph 410,4	OIL&G 413,1	As, T 206,3	CU,T 220.1	Cu,S 220,1	Fo,T 236,1	Fo,S 236.1	Pb,T 239,1	NI,T 249,1	NI,S 249.1	Zn,T 289,1	Zn,S 289,1	Cr,T 218.1	Mn,T 243.1	Ba,T 206.1	Cd 282.1	Sn,T 282.1	COD 410.4	SETT. 160.5	Ba,T 160,2
93-06.20	HERACLES	B. TANK #2	445.93	WET	7.15	NA	NA	0.66	NA	NA	NA	NA	NA	NA	3.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
93-04-03	HERACLES	BARNACLES	1001-93	WET	NA	NA	NA	<1	NA	NA	NA	NA	NA	NA	42	NA	NA	NA	NA	NA	NA	NA	NA	NA
93-B1-01	SPICA	B. TANK #l	491.93	WET	7,72	NA	NA	3.45	NA	1.54	NA	<0.05	<0.05	NA	1.85	NA	NA	NA	NA	NA	NA	NA	NA	NA
93-B2-01	SPICA	B. TANK #2	491-93	WET	7.52	NA	NA	2.50	NA	2.34	NA	0.54	<0.05	NA	1.58	NA	NA	NA	NA	NA	NA	NA	NA	NA
93-DS-01	SPICA	DRIP ZONE	491.93	WET	7.71	NA	NA	40.3	NA	16.4	NA	<0.05	<0.05	NA	17.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
93-N-01	SPICA	NOZZLE	491-93	WET	8.13	NA	NA	0.39	NA	2.46	NA	<0,05	<0.05	NA	0.32	NA	NA	NA	NA	NA	NA	NA	NA	NA
93-6-24	SPICA	B. TANK #l	481-2.93	WET	NA	NA	NA	4.48	NA	NA	NA	NA	NA	NA	2.28	NA	NA	NA	NA	NA	NA	NA	NA	NA
93-06-25	SPICA	B. TANK #2	481-2-93	WET	NA	NA	NA	3.47	NA	NA	NA	NA	NA	NA	2.00	NA	NA	NA	NA	NA	NA	NA	NA	NA
AC-FALL	CHANCE	HULL FALL	607.3 TO 17-93	WET	4.2	NA	NA	44.1	2.5	14.2	0.13	<0.1	3.9	<0.05	23.6	2.6	0.2	0.08	<1.0	<0.05	<2.0	371	5.0	335,0
AC-SUMP	CHANCE	SUMP	607-1-93	WET	7.1	1010	<0.03	19.4	3.2	11.9	NA	NA	NA	NA	6.6	0.6	NA	NA	NA	NA	2.2	NA	NA	NA
AC-NOZZLE	CHANCE	NOZZLE	607-20,21.93	WET	8.1	NA	NA	<0.05	NA	NA	NA	NA	NA	NA	0 2	NA	NA	NA	NA	NA	NA	NA	NA	NA
AC-15	CHANCE	BLANK-DL	607.18,19-93	WET	4.2	NA	NA	<0.05	NA	NA	NA	NA	NA	NA	<005	NA	NA	NA	NA	NA	NA	NA	NA	NA
SETT. SOLIDS VIAL	CHANCE	SETT, SOLIDS	NA	DRY																				
SOOLIDE	CHANCE	SUMP	NA	DRY																				
94-T-01 TO 06	PRINCESS	TANK	114.94	WET	7.04	9.7	NA	2.29	0.85	9.23	<0.05	<0.1	0.44	NA	1.21	NA	<005	050	<10	<0.05	<30	863.0	<0.2	49.0
AC-FALL	VIKING	FULL FALL	i59-(2, 3, 4).94	WET	8.32	<1.0	STILL	11	0.61	38	0.25	<0.1	0.29	NA	12	014	<005	029	<10	<005	<30	374	1.5	490
AC-SUMP	VIKING	SUMP	159-1-94	WET	7.4	<5,0	STILL	13	0.44	181	<0,05	<0.1	19	<005	1.4	NA	024	062	17	<005	<30	356	06	194
AC-NOZZLE	VIKING	NOZZLE	159-5-94	WET	823	NA	NA	<0,05	NA	NA	NA	NA	<0.05	NA	<005	NA	NA	NA	NA	NA	NA	NA	NA	NA
AC-4	VIKING	BLANK.DL	159-6-94	WET	6.99	NA	NA	<0.05		NA	NA	NA	<0.05	NA	<005	NA	NA	NA	NA	NA	NA	NA	NA	NA
SETT. SOLIDS VIAL	VIKING	SETT. SOLIDS	NA	WET		NA																		
NSRP WATER FILTRATION STUDY, PHASE I																									
CALCULATIONS																									
HULL AVERAGE					6.74	NA	NA	31.8		22.87		0	2.1		17.53		0.1	0.185	0	0	0	536	3.25	412.5
HULL RANGE					4.12	NA	NA	33		23.8		0	3.9		11.6		0.2	0.21	0	0	0	489	3.5	155
HULL % DISSOLVED	CHANCE								5.67%		0.92%			0		11.02%								
	VIKING								5.55%		0.66%			NA		1.17%								
SUMP AVERAGE					7.23	505	.005	16.2		96.45		NA	NA		4		NA	NA	NA	NA	1.1	NA	NA	NA
SUMP RANGE					0.3	1010	0.009	6.4		169.1		NA	NA		5,2		NA	NA	NA	NA	2.2	NA	NA	NA
SUMP % DISSOLVED	CHANCE								16.49%		0.66%			NA		9.09%								
	VIKING								3.38%		0.00%			0		NA								

Table 5-2: Phase ISampling Program Analytical Results

It’s plausible that there is a dilution effect from the source to the sump, since as water runs off the dock, some of the particulate contaminants settle before they reach the sump. Additionally, water from various other sources runs off to the sump, thereby diluting the run-off water. Both of these phenomena were observed during sampling events. A thick layer of paint covered the dock floor after each hydroblasting operation, including a high sedimentation rate on the dock floor. A dilution effect could be countered for some analyses by the hydroblast water accumulating other contaminants as it runs off.

For example, some of the abrasive grit particles become suspended as noted above and do not settle quickly. Abrasive copper slag is a misnomer, since it is composed of approximately one percent copper and twenty two percent iron. Copper slag and steel shot, or Black Beauty (coal slag), are the residual solids from refining processes, which are recovered and used for abrasive blasting. The laboratories’ protocol is to aliquot a representative sample of what they receive, and digest the sample with acid into solution so that the grit particles contribute a significantly higher proportion to the metals analytical results than the paint particles, despite the fact that copper grit is formulated not to leach and antifoulant paint is designed to leach.

There were not enough samples collected from HERACLES SPIRIT and FAIR PRINCESS to investigate the dilution effect within the scope of the project. SPICA and CHANCELLORSVILLE samples consistently show a dilution effect for copper, iron, and zinc; the hull samples are consistently at higher concentrations than the baker tank samples. VIKING SERENADE shows the opposite of a dilution effect; the sump sample has a higher concentration of copper, iron, and nickel than the hull sample. Only the zinc was lower in the sump than in the hull sample.

As discussed above, VIKING SERENADE sump settleables contained several grit particles. These suspended grit particles are probably the cause of the sample exceeding the discharge limits for copper, iron, and nickel. VIKING SERENADE hull and sump samples contained disproportionate concentrations of iron, copper, and nickel, and VIKING SERENADE soluble fractions are also consistently lower than CHANCELLORSVILLE, supporting the hypothesis that slag particles are the origin of the copper and iron. The settleable solids were not retained for CHANCELLORSVILLE so it is not known whether the sump sample contained grit particles. In conclusion, more data is needed to substantiate the dilution effect. The dissolved fraction of the hull and sump samples ranged from O - 16%. The low settleable solids content indicates the majority of metals are suspended.

NASSCO is regulated under federal category metal finishing sewer discharge limits which are much lower than POTW limits in the majority of cases. NASSCO’s pH limit is a range of 5 to 11, and all the samples except for

CHANCELLORSVILLE hull and blank samples were within this range. The same container of deionized water was used for both blank samples for VIKING SERENADE and CHANCELLORSVILLE, indicating CHANCELLORSVILLE's blank pH result is possibly error introduced by the laboratory. NASSCO's oil and grease monthly limit is 500 ppm and only one sample exceeded this. The high oil and grease result of 1,010 ppm in CHANCELLORSVILLE coincides with a small amount of oil discharged to the dock floor which occurred the day before sampling. With good waste segregation practices (i.e. drip pans), oil and grease should not be a significant contaminant in runoff water, since the source of any organic contaminants (including benzene, toluene, and xylene) in runoff water is primarily diesel fuel and solvents.

Arsenic, lead, chromium, manganese, barium, and cadmium were not present in “significant quantities; only one of the lead results was greater than the monthly limit of .43 ppm. Only two samples contained nickel in an amount greater than the monthly sewer discharge limit of 2.38 ppm. In general, nickel was present in quantities below the sewer discharge limits. Copper and zinc were present in concentrations which were generally greater than the metal finishing sewer limits. All the wastewater samples for SPICA, CHANCELLORSVILLE, FAIR PRINCESS, and VIKING SERENADE were over the sewer discharge limits for copper and zinc (2.07 ppm and 1.48 ppm respectively). The nozzle and blank samples from CHANCELLORSVILLE and VIKING SERENADE did not contain copper and the nozzle sample for SPICA had a small quantity of .39 ppm. Zinc was present only in the nozzle sample from CHANCELLORSVILLE. Tin was not detectable in any of the samples with the exception of 2.2 ppm in the sump sample from CHANCELLORSVILLE. This result was unexpected since FAIR PRINCESS and VIKING SERENADE were painted with tin based antifoulant.

Several shipyards partiapating in the survey reported lower copper limits than NASSCO’s monthly limit of 2.07 ppm, and would also have had to treat the hydroblast wastewater. Most of the other shipyards would have to treat the hull and sump wastewater for zinc as well. With the exception of one yard who has limits in the parts-per-billion range for discharges to receiving water, none of the other metals would have been a problem for most the other shipyards. Total suspended solids (TSS) and chemical oxygen demand (COD) were not regulated for any of the shipyards in the survey except one. At NASSCO, total toxic organics (TTO) are regulated. TSS results varied from 49 ppm to 490 ppm, but COD results were consistent with one another at approximately 370 ppm (except for one high result of 863 ppm for FAIR PRINCESS). The results correlate to medium strength sewage. Chemical analysis results agree with the conclusions from Kenneth Alexander’s thesis, and generally agree with the Maritime Industrial Waste Project and EPA guidelines document conclusions.

Particle size analysis of the sump solids from CHANCELLORSVILLE reveal that 85% of the particles are between 20 and 100 microns. Particle size results correlate extremely well with the Maritime Industrial Waste Project and the EPA guidelines

document conclusions.

In conclusion, incorporating best management practices (BMPs) and waste segregation techniques can prevent wastewater from requiring any treatment besides gravitational settling. Further, the sampling point strongly influences whether the wastewater will be over sewer discharge limits. Sampling after simple settling, especially when grit is present, facilitates meeting discharge limits without treatment in many instances.

SECTION 6

CONTAINMENT METHODS

6.1 Containment Methods Currently Used by Shipyards

From the shipyard survey many shipyards did not have a collection system to contain the hydroblast wastewater generated during ship repair. Other shipyards have implemented a collection system within their dock facility to collect hydroblast wastewater. Such a system consists of a collection trough that drains into a sump area. The water is then pumped into a storage tank located near the sump area.

6.1.1 Floating Dry Dock Containment Systems

From the survey, various shipyards' segmented floating dry docks had containment systems for collection of hydroblast wastewater on the dock floor. The wastewater was removed with submersible pumps. The segmented section of the dock was protected by covering the open grated areas of the docks. The areas were covered with plastic sheeting, and sand bags were laid over the plastic sheeting.

Another shipyard covered the openings with plywood and used marine caulking at the joints to prevent any leakage from the segmented areas. The hydroblast wastewater was collected in each section of the hydroblasting area of the ship. A channel was constructed to allow the wastewater to collect along the wall of the dock and flow across the sectional area where plastic sheeting or square plastic piping collected the water at the end of the dock in a sump collection area.

The wastewater collected at the sump was either transferred to a storage tank on the dock, or pier, or to the wingwall storage section of the floating dry dock. Many wingwalls on floating dry docks have large storage capacity. This capacity is not always usable due to the dry dock stability issues. Shipyards commonly use rented or leased storage tanks for the hydroblast and bilge wastewater generated during the repair operation. Some shipyards are attempting to segregate different types of wastewater by the types of contaminants generated during hydroblasting, abrasive blasting, tank cleaning, bilge water, or fuel compensated ballast water. The contaminants from these operations may affect the quality of the recovered oil. Treatment may be needed to ensure the value of the oil on the resale market.

6.1.2 GravIng Dock Containment systems

The graving dock usually has an existing collection system or drainage trough which can be used for hydroblast containment. The survey showed that some shipyards had designed collection systems that allowed the hydroblast wastewater to be collected in underground vaults for storage. Other systems pumped wastewater to an aboveground storage tank located in the graving dock or placed at the working level of the dock. Some collection systems allowed the wastewater to be diverted to a collection tank during hydroblasting or switched to sewer or receiving waters when hydroblasting was not being performed. The graving dock floor has a natural slope allowing easy drainage during the blasting operation. The pumping system can be redesigned to allow for diversion, however the conversion from one system to another could be expensive.

6.1.3 Building Ways Containment Systems

The collection of wastewater in building ways is not common due to limited usage of building ways for hydroblasting operations. A few shipyards were planning to convert iheir building ways to collect wastewater or rainwater that may come in contact with shipyard waste. Some shipyards had constructed a berm to segregate gate leakage from wastewater generated during the building operation. This was accomplished by the use of sand bags or angle iron, which prevented the two waste streams from coming in contact with one another. One shipyard uses a portable collection system at the site of generation. With a large vessel, the system would have to be constantly moved to collect the wastewater, which could be considered a disadvantage.

Some of the newer building ways have collection systems that can be segregated from the pumproom and allow separate collection systems to be constructed. Many of the older building ways have no collection system and drain directly into the receiving water. With this type of system, the simplest method of collection is to berm gate leakage and collect hydroblast wastewater with a portable sump pump on the ways floor. All gate leakage would be pumped to the receiving water. Wastewater from the hydroblasting operation would be pumped to an aboveground storage tank.

6.1.4 Marine Railway Containment Systems

This type of haul-out or launch dock presents the most serious problem. The receiving water may be very. close to the vessel, limiting the area to lay out a collection system under the vessel. The plus side is that marine railways are usually used on smaller vessels; The survey showed that some shipyards were collecting hydroblast wastewater by building a berm system at the base of the dock with a vee collection or diagonal to direct the wastewater to a submersible pump. If the area is affected by tidal action, two or more berm systems may have to be constructed depending on the configuration of the marine railway. Again, the waste-

water is pumped to a collection tank for treatment or to the sewer for disposal. Some newer shipyards have a trough system at the base of the marine railway allowing collection of wastewater.

6.2 Containment Methods Used at NASSCO

NASSCO has similar collection systems to those used at many shipyards that were surveyed. The only minor difference is the degree of segregation that is performed at NASSCO. The design and equipment used for each containment and collection system at NASSCO will be explained. NASSCO does not have a marine railway.

6.2.1 Floating Dry Dock

NASSCO's floating dry dock is a self-contained and non-sectional dock with an overall length of 585 feet and beam of 170 feet (140 clear between wingwalls). Figure 6-1 gives a general outline of the floating dry dock and the collection system that services the dock. A storm water diversion system is also an integrated part of the collection system.

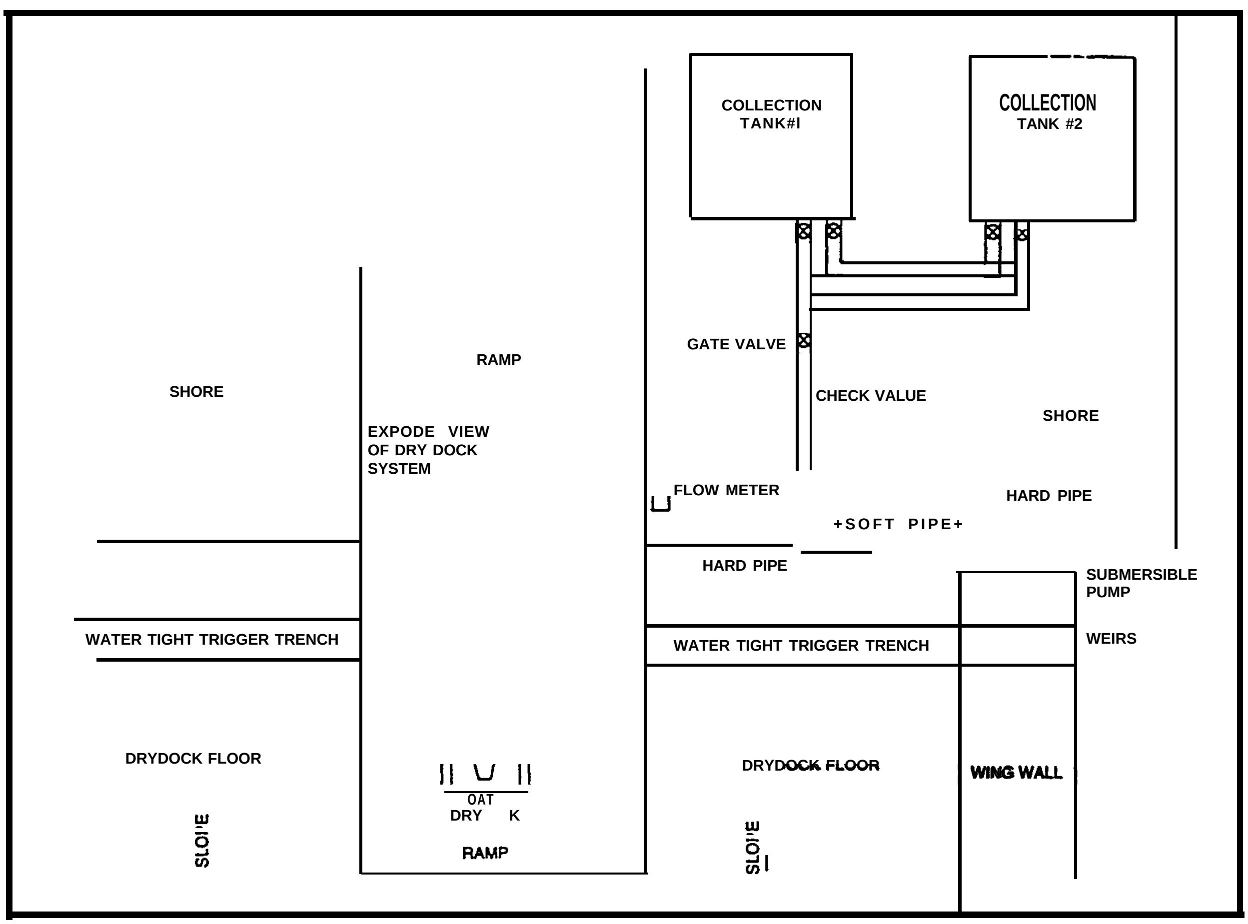


Figure 6-1: NASSCO'S Floating Dry dock Collection System

The collection system consists of a water trough at the head of the dock, which empties into a 100-gallon capacity sump on the starboard side of the dock. A 200-gallon per minute submersible pump is used to remove the water from the sump through a 4-inch flex hose attached to a 4-inch steel pipe at pier level. The steel pipe feeds to two 22,000-gallon aboveground storage tanks located on the pier.

The pumping system is controlled by an electronic controller with a switch for setting the mode of operation. The pump has a float switch monitors the level in the sump. The two basic operations for the controller are continuous pumping on demand and storm water diversion. The continuous pumping is used when the dock is being used during a repair operation with possible contamination on the dock floor. All wastewater collected during this operation is pumped to the two 22,000-gallon storage tanks on the pier.

Under the storm water diversion mode of operation, all storm water on the dock is collected until one tenth of an inch in volume has been collected from the dock floor. At this point, the pump will shut down and the sump is allowed to overfill and flow into San Diego Bay. The drawback with this type of storm water diversion system is that the dock floor may not be contaminated from such operations as hydroblasting, abrasive blasting, and painting or paint chips and collections would not be required. If contaminants are present, the system would be in the continuous mode of operation with no storm water diversion to the bay.

6.2.2 Graving Dock

NASSCO's graving dock is constructed with a concrete floor and steel sheet pile walls. The overall length is 1,000 feet and width is 178 feet. Figure 6-2 gives a general outline of the graving dock and the collection system that services the dock. The dock also has a storm water diversion system, which is part of the general drainage system for dewatering the dock.

The operation of the collection system consists of two longitudinal floor drain culverts near the sidewalls that lead to the midsection collection sump. A 1,000-gallon per minute submersible pump is used to transfer the wastewater to a 22,000-gallon aboveground storage tank located in the graving dock. After the wastewater is analyzed, the water is either transferred by truck or pipeline to the wastewater treatment facility or discharged directly to the sewer.

The pumping system is controlled by the same controller used for the floating dry dock and is part of the storm water diversion system for the graving dock. To avoid any possible discharge to San Diego Bay during hydroblasting operations, the controller is switched to the collection mode and all wastewater is directed to the 22,000-gallon storage tank.

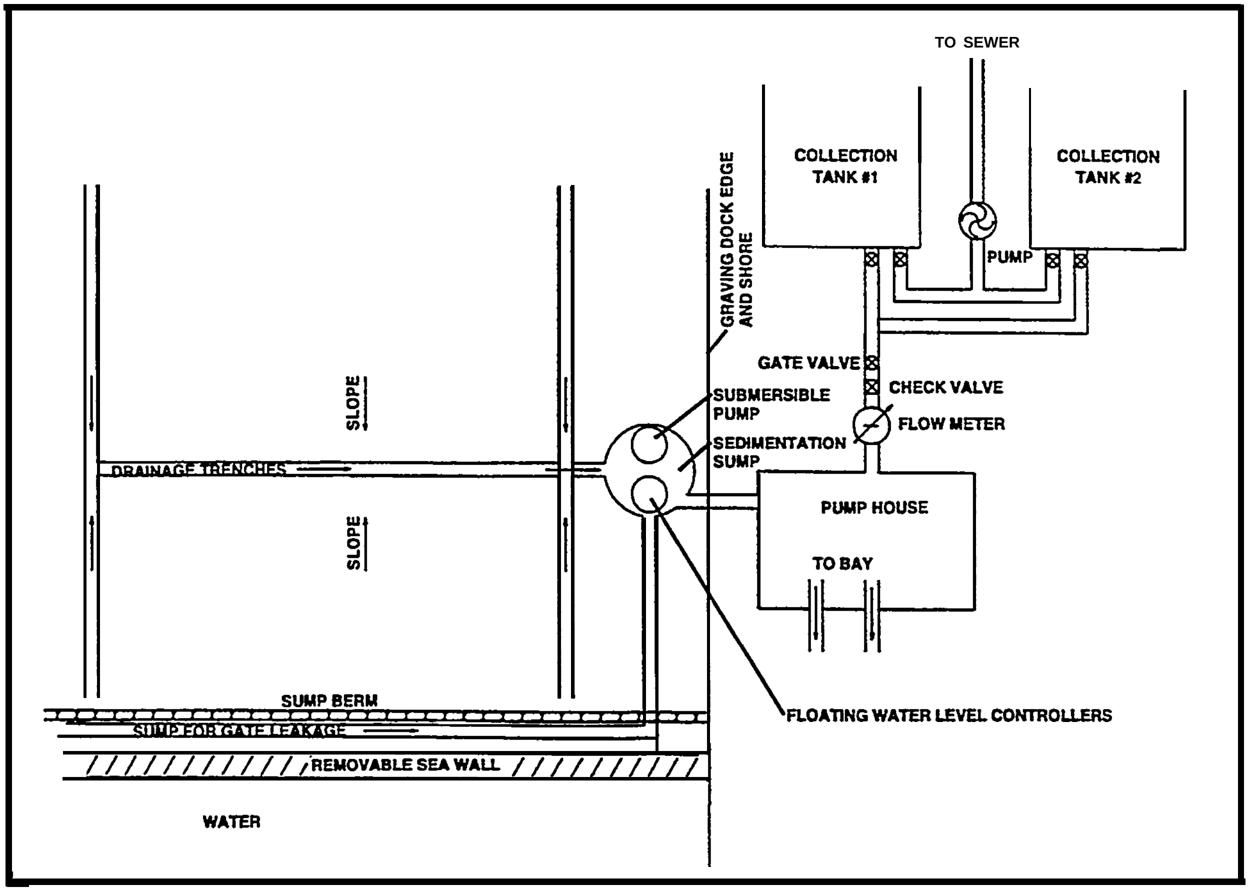


Figure 6-2: NASSCO's Graving Dock Collection System

6.2.3 Building Ways

NASSCO has two building ways that are used for new construction. The construction of the ways is very similar to the graving dock with the exception that the ways floor is at an incline and has a drainage system under the floor. Figure 6-3 outlines the collection system. The ways has a storm water diversion system similar to that used in the graving dock and floating dry dock. The only differences are the ways floor drainage to the sump and the berm segregation to separate gate leakage from ways floor drainage.

The operation of the collection system is the same as the graving dock sump collection system and the electronic controller is the same type of controller.

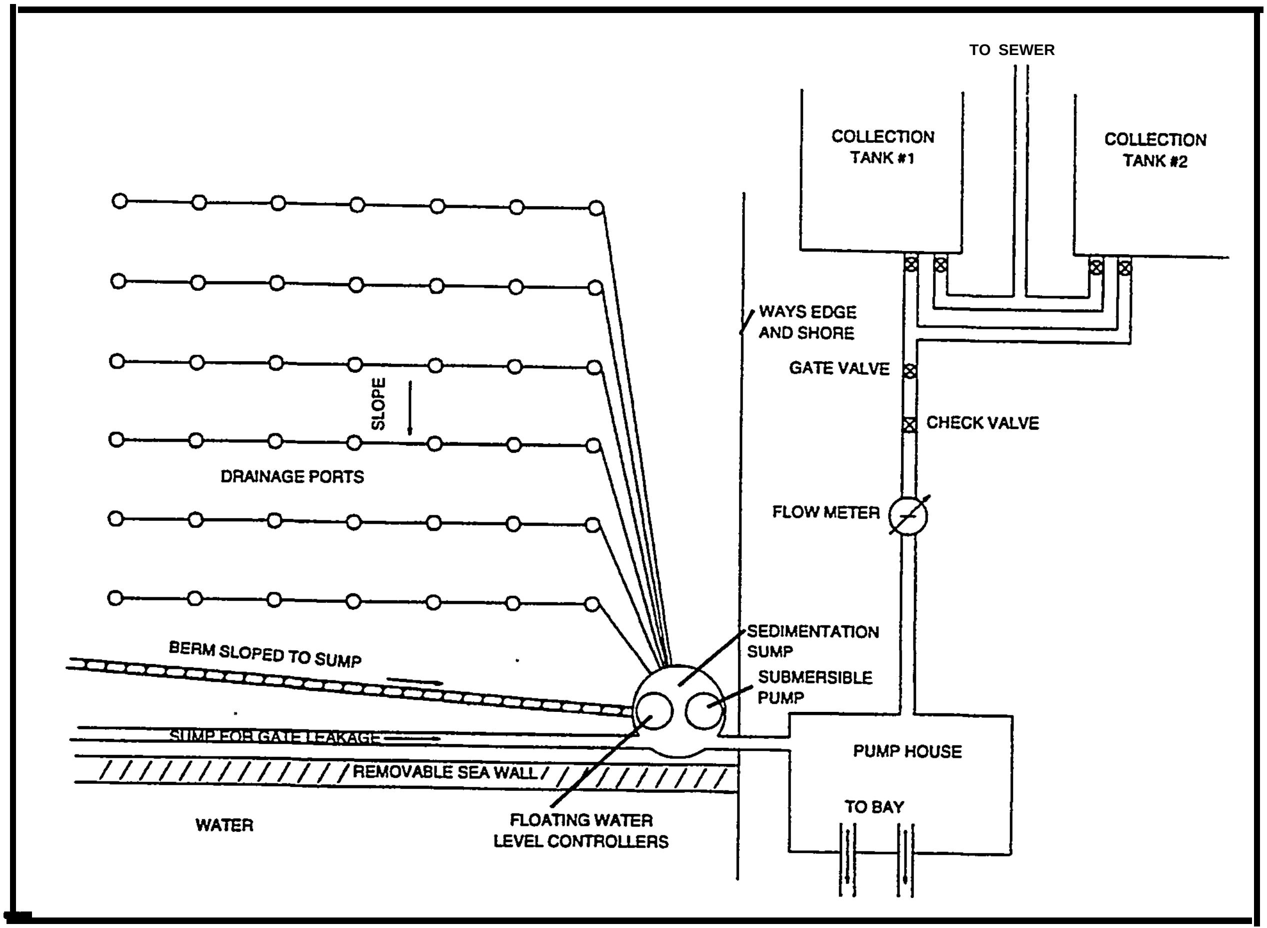


Figure 6-3: Ways floor Collection System

SECTION 7

TREATMENT SYSTEM REQUIREMENTS

7.1 Regulatory Requirements

The Federal Water PoIlution Control Act (FWPCA) of 1972 established a program to restore the integrity of the nation's waters. Congress directed the Environmental Protection Agency (EPA) to issue effluent limitation guidelines and pretreatment standards for industrial dischargers. These regulations were based on degree of effluent reduction obtainable through the application of control technologies. The approach includes technologies based on Best Practicable Control Technology (BPT), Best Available Technology Economically Achievable (BAT), and Best Conventional Pollutant Control Technology (BCT). New industrial direct discharges were required to comply with New Source Performance Standards (NSPS) and new and existing discharges to publicly owned treatment works (POTW's) were subject to pretreatment standards under Pretreatment Standards for Existing Sources (PSES) and Pretreatment Standards for New Sources (PSNS).

The limitations and standards are implemented in permits issued through the National Pollutant Discharge Elimination System (NPDES) for point sources discharged directly to the waters of the United States. The limitations are based on performance capabilities of a particular control technology including, in some cases, in-process controls. The dischargers may meet the requirements using whatever combination of control methods they choose, such as manufacturing process or equipment changes, product substitution, and water reuse and recycling. Categorical pretreatment standards are applicable to indirect discharges to POTWs.

Shipyards in the United States are regulated under both direct and indirect standards in the majority of cases. The hydroblast wastewater at some shipyards is discharged directly into the receiving waters, while other shipyards discharge the wastewater indirectly to the POTW. With the increase in required treatment technology, more shipyards are redirecting this specific waste stream to the local POTW since the discharge standards maybe less stringent than the direct discharge standards. Many shipyards are currently regulated under the Metal Finishing Federal Category Pretreatment standard, while other shipyards are not under any pretreatment standards for discharges to a POTW. Future pretreatment standards are being proposed under a new pretreatment standard called Metal Products and Machinery (MP&M Phase II) category standard. Since each shipyard may currently be under different standards, each shipyard must research which technology will achieve the desired discharge standards for their facility and plan for the future standards that will be implemented for the shipbuilding industry.

7.2 Technical Requirements

The objective of this wastewater filtration project is to identify methods for the treatment of wastewater from pressure washing that reduce or remove the contaminants to concentration levels that allow the wastewater to be discharged to the local POTW or receiving waters. From the wastewater characterization study discussed in Chapter 5 and other studies cited, a determination was made that wastewater contaminants would need to be reduced or removed to allow for proper discharge to POTW or receiving waters. The most feasible and cost effective approach for the treatment of this type of wastewater is discharge to the local POTW if possible.

Due to the stringent discharge standards that are imposed on receiving water discharge within a shipyard NPDES permit, the POTW discharge approach may be the most cost-effective. With the decreasing treatment discharge limits proposed for the future, this approach may be the only one a shipyard can reasonably afford. From this study and other studies, the following technologies have been identified as possible wastewater treatment technologies which could be used to discharge to the local POTW. Each of these technologies have certain defined levels of contaminant reduction and treatment costs associated with the unit operation.

7.3 Wastewater Treatment Technologies

7.3.1 Gravity Separation-Clarification

Using gravity, clarification systems provide continuous low-cost separation and removal of suspended solids from water. Clarification is used to remove particles, flocculated impurities, and precipitates. These systems typically follow wastewater treatment processes that generate suspended solids, such as chemical precipitation and biological treatment.

Clarification units are often preceded by flocculation steps to promote settling. The flocculation process involves the addition of treatment chemical, or flocculants, to the wastewater. The flocculent is rapidly mixed with the wastewater for uniform dispersion. In the clarifier, wastewater is allowed to flow slowly and uniformly permitting the solids denser than water to settle to the bottom. The clarified wastewater is discharged by flowing over a weir at the top of the clarifier. Conventional clarifiers typically consist of a circular or rectangular tank. The more specialized clarifiers incorporate tubes, plates, and lamellar networks to increase the settling area. The sludge that accumulates at the bottom is periodically removed and must be dewatered and disposed. A clarification system diagram is shown in Figure 7-1.

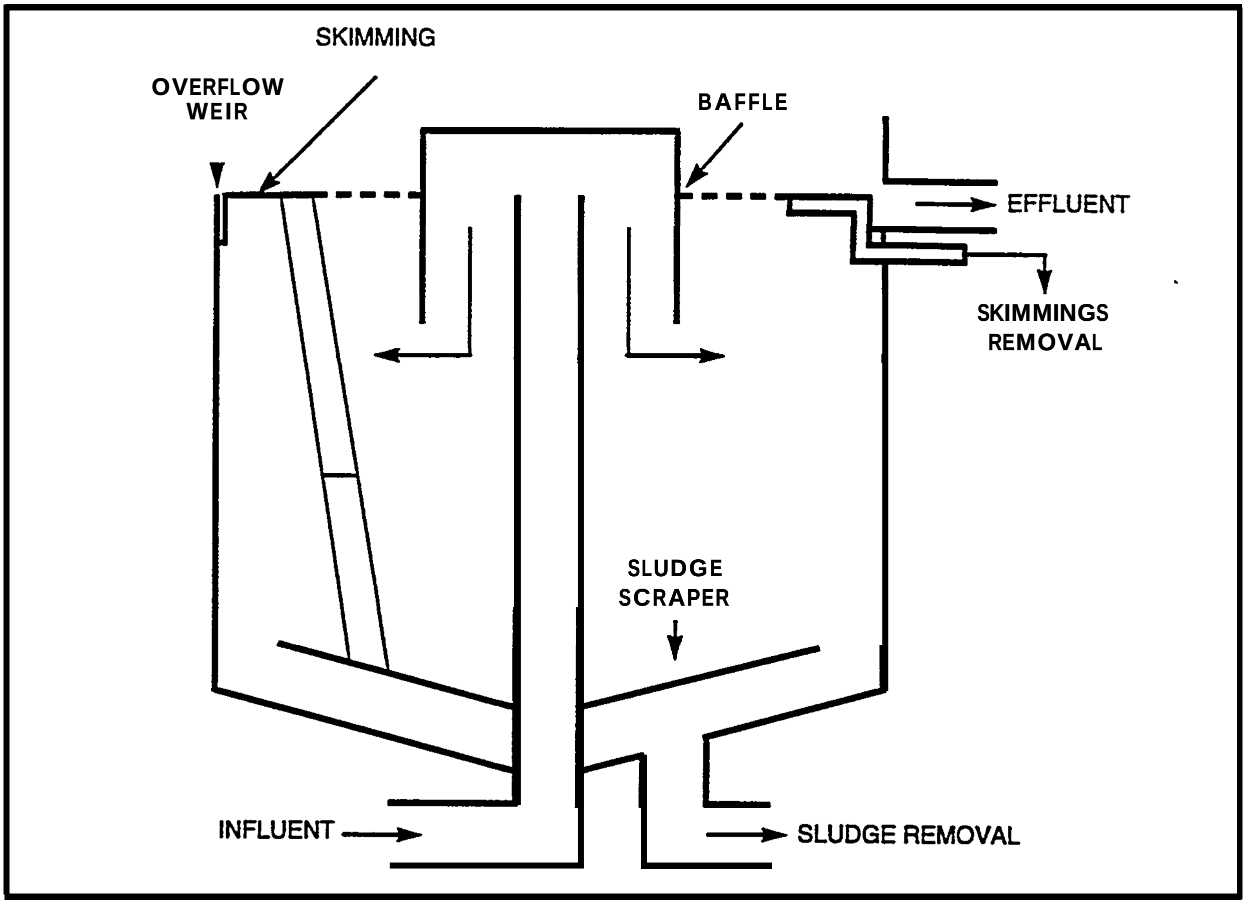


Figure **7-1: Clarification System Diagram**

7.3.2 Filtration-Plate and Frame Pressure

Plate and frame filtration systems are used to remove solids from waste streams. The plate and frame filter press consists of a number of filter plates or trays connected to a frame and pressed together between a fixed end and a moving end. Filter cloth is mounted on the face of each plate. The water is pumped into the unit under pressure while the plates are pressed together. The solids are retained in the cavities of the filter press and begin to attach to the filter cloth until a cake is formed. The water, or filtrate, passes through the filter cloth and is discharged from the drainage port in the bottom of the press. The wastewater is pumped into the system until the cavities are filled. Pressure is applied to the plates until the flow of filtrate stops.

At the end of the cycle, the pressure is released and the plates are separated. The filter cake drops into a hopper below the press. The filter cake can then be disposed in the proper regulated manner (Subtitle C or D landfill site). The filter cloth is then washed before the next cycle begins.

The key advantage of the plate and frame pressure filtration is that it can produce a dry filter cake, which is not possible with other filtration methods. The

batch operation of the plate and frame press makes it a practical method for the filtration of batch wastewater. A typical plate and frame pressure filtration system diagram is shown in Figure 7-2.

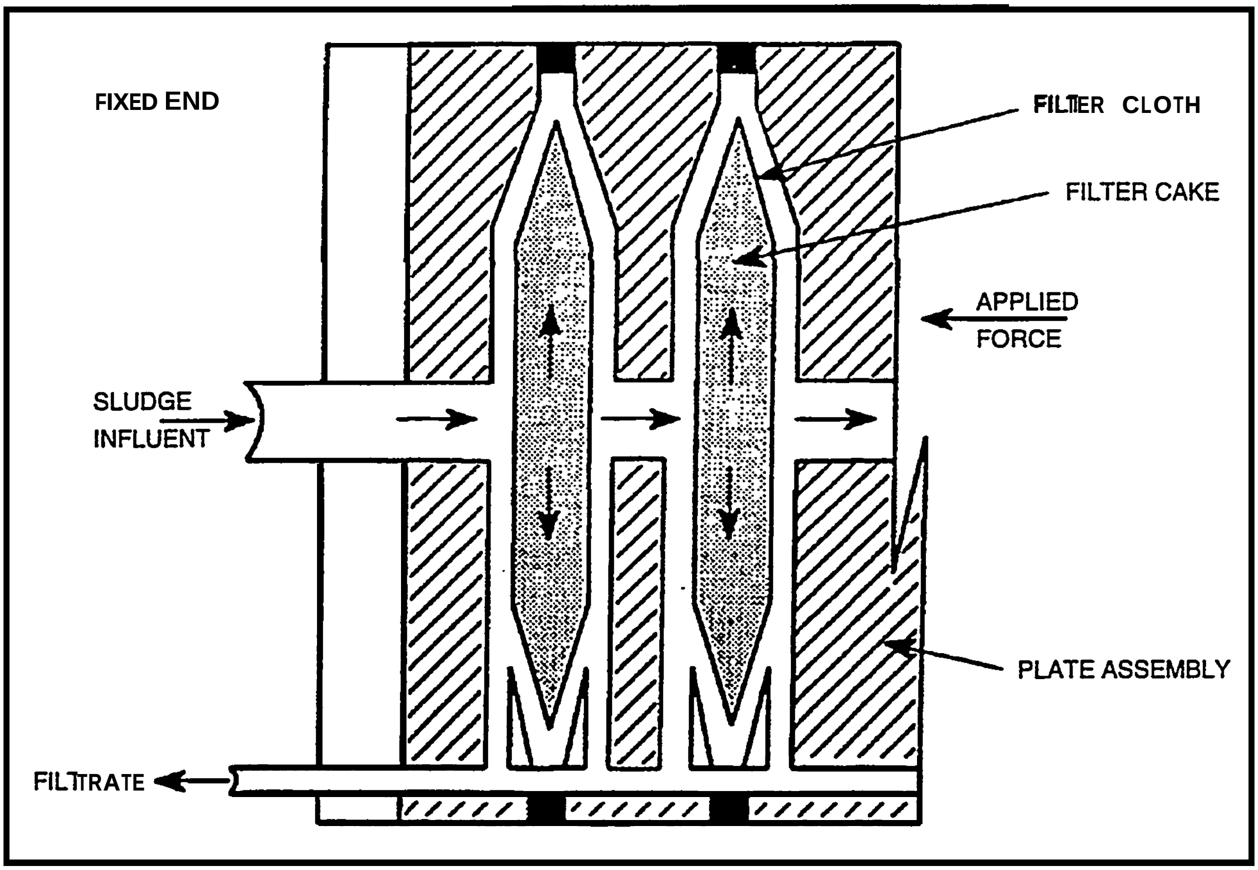


figure 7-2: Plate and Frame Pressure Filtration System Diagram

7.3.3 Filtration with Mono- and Multi-Media

Multi-media or granular bed filtration is used for removing residual suspended solids from wastewater. In granular bed filtration, the wastewater stream is sent through a bed containing one or more layers of different granular materials. The solids are retained in the voids between the media particles while the wastewater passes through the bed. Typical media used in granular bed filters include anthracite coal, sand, and garnet. These media can be used alone, such as in sand filtration, or in a multi-media combination. Multi-media filters are designed so that the individual layers of media remain fairly discrete. This is accomplished by selecting appropriate filter loading rates, media grain size, and bed density.

A multi-media filter operates with the finer, denser media at the bottom and the coarser, less dense media at the top. A common arrangement is garnet at the bottom of the bed, sand in the middle, and anthracite coal at the top. Some mixing of these layers will occur. During filtration, removal of suspended solids is

accomplished by a complex process involving one or more processes, such as straining, sedimentation, interception, impaction, and absorption. The media size is the principle characteristic affecting the filtration operation. If the media is too small, much of the driving force will be wasted in overcoming the frictional resistance of the filter bed. If the media is too large, small particles will travel through the bed, preventing optimum filtration.

The flow pattern of multi-media filters is usually top-to-bottom. Upflow filters, horizontal filters, and biflow filters are also used. The top-to-bottom multi-media filter is represented in Figure 7-3. The classic multi-media filters operate by gravity; however, pressure filters are occasionally used.

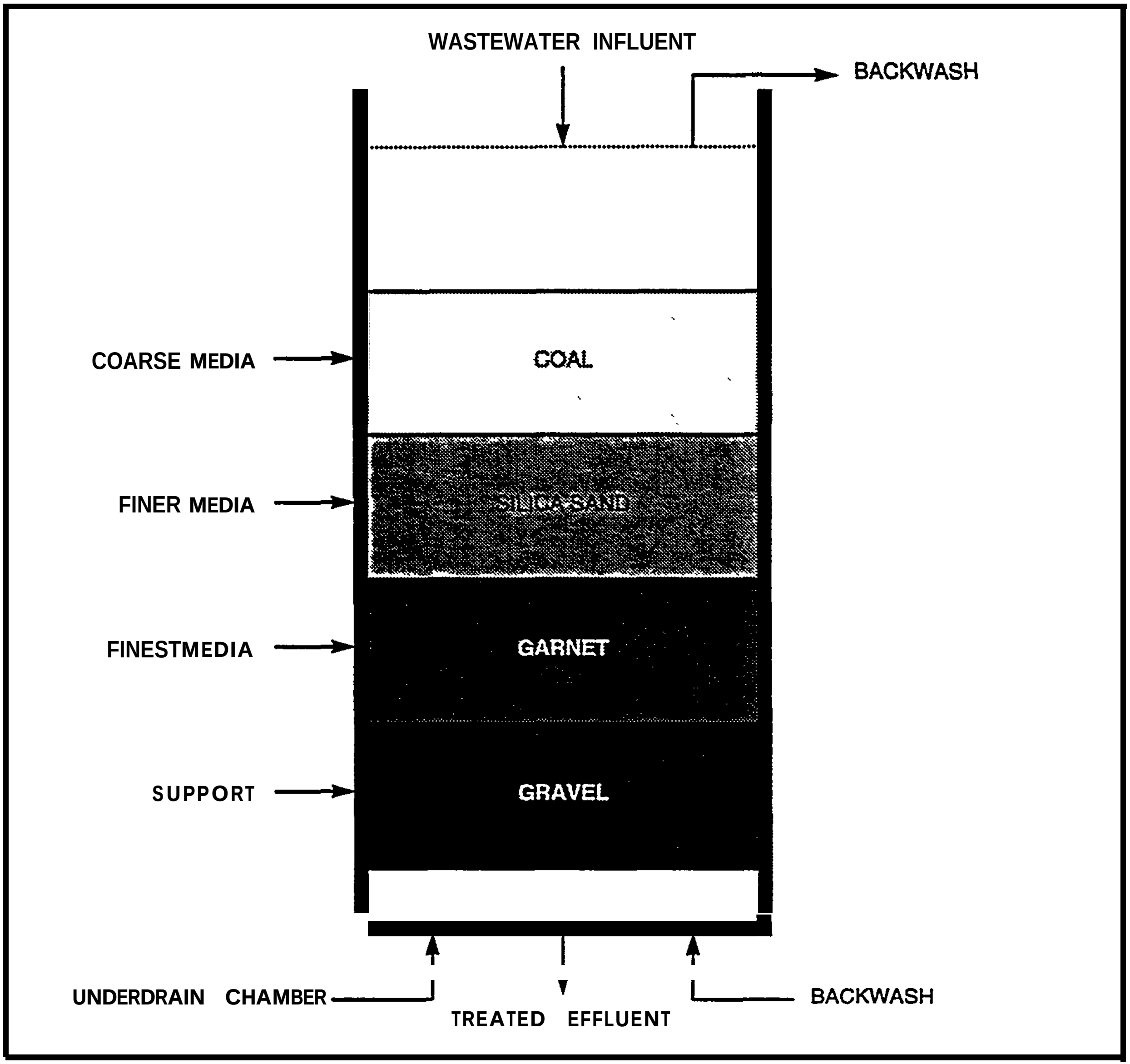


Figure **7-3: Top-to-Bottom Multi-Media Filtration System Diagram**

The complete filtration process involves two phases—filtration and backwashing. As the filter becomes filled with trapped solids, the efficiency of the filtration process falls off. Head loss is a measure of the solids trapped in the media. As the head loss across the filter bed increases to a limiting value, the end of the filter run is reached and the filter must be backwashes to remove the suspended solids in the bed. During backwashing, the flow through the filter is reversed so that the solids trapped in the media are dislodged and can exit the filter. The bed may also be agitated with air to aid in solids removal. The backwash water is then recycled back into the wastewater feed stream.

7.3.4 Precoat Filtration

The precoat filtration system, which operates by filtering wastewater through a thin layer of diatomaceous earth supported on fabric, is a variation on the multimedia filtration system. When the filter begins to plug with solids, it is backwashed to remove the plugged media. New media is applied by running a slurry of fresh media through the filter. To avoid rapid plugging, a small amount of the filter media is introduced into the waste stream before filtering. The body feed, as it is called, makes the particulate more porous as it is collected on the filter media and maximzes filter capacity.

7.3.5 Membrane Ultrafiltration

Ultrafiltration (UF) is used to remove substances with molecular weights greater than 500, including suspended solids, oil and grease, large organic molecules, and complex heavy metals. UF system is typically used as an in-plant treatment technology, treating oil/water emulsion prior to mixing with other wastewater.

In UF, a semi-permeable microporous membrane performs the separation. The wastewater is sent through the membrane under pressure. The suspended solids and oil are rejected by the membrane and are removed as a concentrate. The concentrate recirculates through the membrane unit until the flow of the permeate drops. The primary design consideration in UFis the membrane selection. A membrane pore size is chosen based on the size of the contaminated particle targeted for removal. Other design parameters to be considered are solid concentration, viscosity, temperature of the feed stream, and the membrane permeability and thickness. A typical UF system diagram is shown in Figure 7-4.

7.3.6 Requirements for Selection of Treatment Technology

The following requirements for selecting a treatment technology were identified in this project. Suspended solids such as paint chips, marine growth, and spent abrasive used during the hydroblast operation would need to be removed. Removal of other suspended particles, which cannot be removed with simple filtration technology or sedimentation, and dissolved contaminants, which must be removed by secondary treatment technology requiring the use of chemicals or

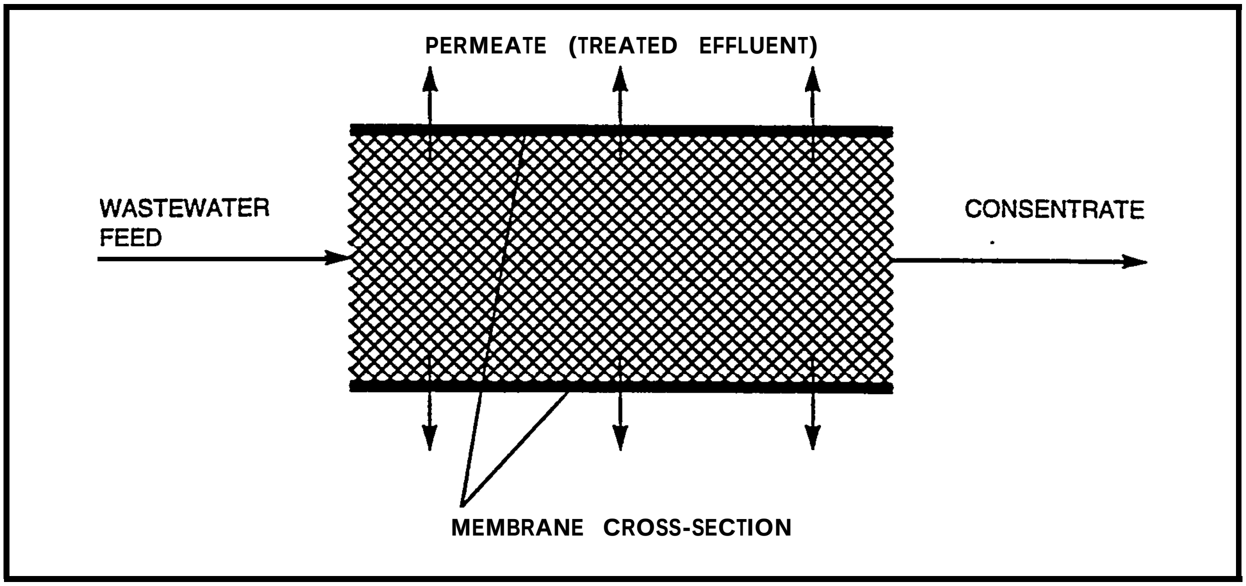


Figure 7-4: **Ultrafiltration System Diagram**

more advanced technology, will be covered in Phase 2 of this project.

In general, the treatment technology should be simple, low cost, effective, and meet the expectations for desired removal or reduction requirements. If large volumes are going to be treated, the technology should be completely automatic to allow simple operation of the treatment unit versus batch treatment. Currently there are many wastewater treatment companies that can provide turnkey systems that meet customer requirements.

To effectively select the correct treatment system, a vendor should evaluate the shipyard's needs, evaluate the source of wastewater, the contamination levels, and evaluate this information against discharge limits. The discharge limits should be evaluated for future changes and other possible sources of wastewater that may be treated at the shipyard (bilge and ballast wastewater).

7.3.7 Additional Criteria to Evaluate

Depending on the collection or contaminant site, multiple sumps may be needed to separate gate leakage or ground water seepage from the hydroblast waste-water process operation. The pumping system from the sump to the storage tank or treatment system should be the correct diameter to allow the proper flow rate and prevent any damage to the pump due to back pressure resulting from incorrect size or restriction within the line. All collection and treatment systems must have easy access for repair and maintenance to provide fast and reliable service of the treatment unit.

SECTION 8

ANALYSIS OF SELECTED PRETREATMENT METHODS

8.1 Selection Methodology of Selected Methods

The selection of any treatment system is only good if it meets the expectation of the wastewater treatment standard. When selecting a particular treatment system, the discharge treatment or POTW limits must be evaluated against the designed treatment range. The treatment system must be flexible so that any future discharge limit changes can be met. Items to review for the selection of a treatment system include the following

- Request information on technology that has been used at similar shipyard facilities or similar applications.
- Select the best discharge route versus treatment standard to meet POTW or receiving water limits.
- Evaluate the wastewater characteristics or possible contamination. Perform extensive tests on hydroblast waste streams to assure the treatment technology can be selected with sufficient data to support the selection.
- Review the cost, equipment spcification, and site requirements.
- Examine the facility to locate possible sites for the storage and treatment facility.
- Perform prototype or small scale testing of a treatment unit if the treatment system requires different treatment standards.
- Perform an engineering evaluation of the treatment system using basic engineering principles to help evaluate the best system.

8.2 Collection of Hydroblast Wastewater

The shipyard survey shows a typical shipyard may generate an average of 1,000-40,000 gallons of hydroblast wastewater per hydroblasting event. The volume depends on the size of the vessel, the hull configuration, level of cleaning required, equipment used and blast pressure, the number of hydroblasting units, the type of paint system on the vessel, and whether or not slurry blasting was used. From this information, an estimated volume can be determined and a typical flow rate can be estimated from the containment and collection system.

The collection system should have sufficient capacity to hold the volume that may be generated during one full day of hydroblasting operations. The volume

depends on the treatment rate of the system. The discharge rate from the hydroblasting operation may be low, necessitating batch treatment. The volume may be so great that the wastewater must be continuously treated during the hydroblasting process because the volume cannot be stored at the facility. A complete chemical treatment system may be needed if bilge and tank cleaning wastewater is co-generated during the hydroblasting operation.

The facility requirements will need to be addressed in the design phase of the treatment system to cover the possible storage volume and site requirements, pump equipment, and pipeline requirements to transport the wastewater to the treatment site. Some of the general guidelines that should be reviewed during the collection system and storage design phase are listed below:

- All collection drainage areas should provide unobstructed drainage with no holes, cracks, or irregularities that may affect proper drainage of wastewater.
- A collection trench may be needed to support the collection point.
- The sump collection should have sufficient volume to prevent the pump system from recycling too frequently, and a water level control should be used to activate the pump system.

8.3 Cost Analysis

The typical costs for various wastewater treatment technologies are discussed in this section. The following items should be evaluated for the system design:

- Compare the wastewater discharge permit limit with the treatment system design limit and possible future limit.
- Make sure the system treats the correct contaminants to the design discharge limits.
- Evaluate the storage capacity with the required treatment system flow rate to maximize the cost and efficiency of the total system.
- Determine if secondary containment will be required for the treatment site.
- From the wastewater analysis, determine if sedimentation will assist in reduction of contamination and reduce the load rate on the treatment system.
- Evaluate the treatrmint technology for ease and cost effectiveness of maintenance and repair.

Determine if separate treatment systems can be designed to meet the various discharge limits that may be imposed on the shipyard. For example, bilge water

treatment to local POTW limits versus hydroblasting to a federal category discharge limit (metal finishing). Some ship yards may reduce treatment costs because oil-water separation may only need to be performed on the bilge water, whereas the hydroblast wastewater will need to meet federal categorical limits, which require additional treatment, but the volume is much less.

8.3.1 Treatment Technology Costs

Cost information for the selected technologies was available from several sources. The sources for the cost data were engineering literature, vendors' quotations, and EPA wastewater treatment cost studies. All the costs are either scaled up or down to 1989 dollars using the Engineering News Record (ENR) Construction Cost Index. The total cost developed includes the capital cost of the investment and annual operation and maintenance (O&M) costs. The capital cost for the technologies are based on vendors' quotations. The equipment cost typically includes the cost of the treatment unit and some ancillary equipment associated with the technology. The annual O&M costs for the various systems were derived from vendors' information or from engineering literature. The annual O&M costs are comprised of energy, maintenance, taxes and insurance, and labor.

8.3.2 Clarification

The cost for clarification was obtained from vendors. The influent total suspended solids ('ITS) design was 40,000 mg/l or four percent solids. The clarification system includes a clarification unit, flocculation unit pumps, motor, foundation, and necessary accessories. The total construction cost includes the system cost, installation, installed piping and instrumentation, and controls. The O&M costs are determined by energy usage, maintenance, labor, flocculent cost, and taxes and insurance. Tables 8-1 and 8-2 reflect these capital and O&M costs.

VOI/DAY (MGD)	SYSTEM	INSTALL.	PIPING	INSTRUM. AND CONTROLS	ENGlNEER. CONTING.	TOTAL CAPITAL COST (1993 $)	TOTAL CAPITAL (1989 s)
0.000001	6,579	2,303	1,974	1,974	3,849	16.679	15,178
0.00001	6,579	2,303	1,974	1,974	3,849	16,679	15,178
0.0001	6,579	2,303	1,974	1,974	3,849	16,679	15,178
0.001	6,971	2,440	2,091	2,091	4,078	17,671	16,081
0.01	9,547	3,341	2,864	2.864	5,585	24,201	22,023
0.05	14,550	5,093	4,365	4,365	8,512	36,885	33,565
0.1	18,358	6,425	5,507	5,507	10,739	46,536	42,348
0.5	35,466	12,413	10,640	10,640	20,748	89,907	81,815
1.0	49,563	17,347	14,869	14,869	28,994	125,642	114,334

Table 8-1: Capital Costs for Clarification Systems

VOL/DAY (MGD)	ENERGY	LABOR	MAINT.	TAXES AND INSURANCE	POLYMER COST	TOTAL COST (1993 $)	TOTAL O&M COST (1993 s)
0.000001	1,000	15,741	667	334	10	17,752	16,154
0.00001	1,000	15,741	667	334	10	17,752	16,154
0.0001	1,000	15,741	667	334	10	17,752	16,154
0.001	1,010	15,857	706	353	15	17,941	16.326
0.01	1,104	16,842	968	484	150	19,548	17,789
0.05	1,520	18,210	1,475	738	750	22,693	20,651
0.1	2,040	19,005	1,861	931	1,5000	25,337	23,057
0.5	6,155	21,439	3,596	1,798	7,500	40,488	36,844
1.00	11,464	22,788	5,025	2,513	15,000	56,790	51,679

TabLe 8-2: Operation and Maintenance Costs for Clarification Systems

8.3.3 Plate and Frame Pressure Filtration

The plate and frame pressure filtration costs were estimated for a liquid stream; this is the full effluent stream from a hydroblasting operation. The liquid stream consists of 96 percent liquid and 4 percent solids. The components of the plate and frame pressure filtration system include: filter plates, filter cloth, hydraulic pumps, pneumatic booster pumps, control panel, connector pipes, and support platform. The O&M costs were based on estimated electricity usage, maintenance, labor, taxes and insurance, and filter cake disposal cost ($0.74/gal hauling and disposal in subtitle C or D landfill). The capital and O&M costs for plate and frame pressure filtration systems are shown in Tables 8-3 and 8-4.

FLOW (MGD)	AVERAGE VENDOR EQUIPMENT COST ($)	INSTALLATION COST	TOTAL CAPITAL AND INSTALLADTION	ENGINEERING AND CONTINGENCY FEE	TOTAL CAPITAL COST (1989 $)
0.0000O1	6,325	2,214	8,539	2,562	10,102
0.00001	6,325	2,214	8,539	2,562	10,102
0.0001	6,424	2,248	8,672	2,602	10,259
0.0010	9,826	3,439	13,265	3,980	15,693
0.0100	29,316	10,261	39,577	11,873	46,820
0.100	170,575	59,701	230,276	69,083	272,417
1.000	1,935,740	677,509	2,613,249	783,975	3,091,474

Table 8-3: Capital Cost for Plate and Frame Pressure Filtration

FLOW (MGD)	ENERGY	MAINTENANCE	TAXES AND INSURANCE	LABOR	O&M COST (1989 $)
0.000001	1,000	404	202	17,730	19,336
0.00001	1,000	404	202	17,730	19,336
0.0001	1,000	410	205	17,730	19.345
0.001	1,010	627	314	53,549	55,500
0.01	1,104	1,872	936	53,549	57,461
0.05	1,520	5,977	2,989	62,504	72,990
0.1	2,040	10,895	5,446	71,550	89,933
0.5	6,155	55,480	27,740	88,650	176,025
1.0	11,464	123,660	61,830	106,380	303,334

TabLe 8-4: Operation and Maintenance Costs for Plate and Frame Pressure filtration

8.3.4 Multi-Media Filtration

The total capital cost for the multi-media filtration system represents equipment and installation costs. The total construction cost includes the cost of the filter, instrumentation and control, pumps, piping, and installation. The O&M costs include energy usage, maintenance, labor, and taxes and insurance. Tables 8-5 and 8-6 reflect capital and O&M costs for multi-media filtration systems.

FLOW RATE (MGD)	SYSTEM COST	INSTALL	PIPING	INSTRUM. AND CONTROLS	ENGINEER. AND CONTING.	TOTAL CAPITAL COST (1993 $)	TOTAL CAPITAL COST (1993$)
0.001	1,522	761	913	457	1,096	4,749	4,322
0.01	1,942	971	1,165	583	1,398	6,059	5,514
0.05	3,237	1,619	1,942	971	2,331	10,100	9,191
0.10	5,904	2,952	3,542	1,771	4,251	18,420	16,762
0.50	13,098	6,549	7,859	3,929	9,431	40,866	37,188
1.0	27,866	13,933	16,720	8,360	20,064	86,943	79,118

Table 8-5: Capital Costs for Multi-Media Filtration Systems

8.3.5 Ultrafiltration

Capital equipment and operational costs were obtained from manufacturers' quotations. The O&M costs were based on estimated electricity usage, maintenance, labor, and taxes and insurance. The electricity usage and costs were provided by the vendors. The cost of concentrate disposal was quoted at $0.50 per gallon. Tables 8-7 and 8-8 show capital costs and O&M costs for ultrafiltration systems.

FLOW RATE (MGD)	ENERGY	LABOR	MAINT.	TAXES AND INSURANCE	TOTAL O & M COST (1993 s)	TOTAL O & M COST (1993 s)
0.001	1,100	21,900	173	87	23,260	21,167
0.01	1,600	21,900	221	111	23.832	21,687
0.05	1,730	21,800	368	184	24,182	22,006
0.10	7,000	21 ,900	670	335	29,905	27,214
0.50	31,200	21,900	1,488	744	55,332	50,352
1.0	70,000	21,900	3,165	1 ,583	96,648	87,950

Table 8-6: Operation and Maintenance Cost for Multi-Media Foltaration Systems

FLOW (MGD)	AVERAGE VENDOR CAPITAL COST	INSTALLATION COST	TOTAL CAPITAL AND INSTALLATION COST	ENGINEERING AND CONTINGENCY FEE	TOTAL CAPITAL COST (1989 s)
0.00005	17,557	6,145	23,702	7,111	30,813
0.0001	17,730	6,206	23,936	7,181	31,117
0.0005	21,377	7,482	28,859	8,658	37,517
0.0010	25,280	8,848	34,128	10,238	44,366
0.0020	31,325	10,964	42,289	12,687	54,976
0.0100	60,667	21,233	81,900	24,570	106,470
0.0480	142,036	49,713	191,749	57,525	249,274
0.1000	226,365	79,228	305,593	91,878	397,271
1.0000	1,319,323	461 ,763	1,781,086	534,326	2,315,412

Table 8-7: Capital Cost for Ultrafiltration Systems

FLOW (MGD)	ENERGY	MAINTENANCE	TAXES AND INSURANCE	LABOR	CONCENTRATE DISPOSAL COSTS	TOTAL O&M COST (1989 s)
0.000001	1,000	1,232	616	7,607	2	10,457
000001	1,000	1,232	616	7,607	25	10,480
0.0001	1,200	1,232	616	7,607	253	10,908
0.001	2,938	1 ,587	794	7.607	2,536	15,462
0.01	15,068	3,575	1,788	7,607	25,357	53,395
0.05	47,243	7,623	3,812	7,607	126,786	193,071
0.1	77,278	13,398	6,699	7,607	253,571	358,553
1.0	396,329	83,526	41,763	7,607	2,535,71	3,064,939

Table 8-8: Operation and Maintenance Costs for Ultrafiltration Systems

8.4 Benefit Analysis

The major benefit of the installation of a wastewater treatment facility is the reduction in cost of the disposal of any hydroblast and related wastewater that may be generated at the shipyard facility. Many shipyards are being forced to adopt this type of treatment technology by regulators since the wastewater must be treated by a TSDF at the same discharge limit. As a result, the cost of disposal of this type of wastewater on the shipyard has increased. The most cost-effective approach is to treat the wastewater in-house to reduce costs to the shipyard. Many shipyards have implemented different wastewater treatment technologies that best meet their needs, reduce cost to customers, and gain a competitive edge in the current repair work market. Overall, this investment reduces shipyard costs, but future regulatory requirements regarding lower discharge limits may cause this treatment cost to rise. However, shipyards may be forced to invest in a treatment technology in the future due to more stringent limits.

A cost/benefit analysis must be performed by every shipyard to evaluate the cost of investment versus the disposal cost off-site. It may be more cost-effective to ship the wastewater to the local POTW or TSDF if the volume is limited or the cost is being offset by the customer.

SECTION 9

CONCLUSIONS

Due to the changes in environmental regulations and increased public awareness to protect waterways, shipyards are being forced to address handling of hydroblast and related wastewater generated during repair operations. Shipyards must examine current handling and treatment scenarios and determine the most cost effective and environmentally sound methods to meet current and future regulatory requirements (MP&M regulations). To identify the most cost effective method, each shipyard must understand the sources of contamination such as paint solids, sediment, spent blast media, sea growth and toxic metals. Wastewater will need to be characterized by the chemical and physical parameters as outline in this survey. The physical and chemical parameters will assist the selected vendors in providing cost estimates of the different pretreatment technologies recommended. The method of collection and segregation of different types of process wastewater must be planned for to reduce any possible increased treatment cost from contamination from other sources of wastewater.

In the majority of instances, the treatment route for disposal will be to a local POTW, which has less stringent standards than the receiving water discharge limits. Because this method of disposal may be selected, vendors will need to know the discharge limits required by the local POTW. The information provided in this study on literature review, shipyard survey, vendor information and hydroblast characterization will assist each shipyard in understanding the information required to make the proper decision.

From this study and working with vendors, shipyards need to choose the best treatment technologies that meet the economic requirements to treat the waste effluent. Each shipyard should evaluate the application needed and determine if a local TSDF can treat the wastewater at a more cost-effective price. The intent of this project is that shipyards will gain a basic understanding of the treatment options that are available and which treatment technologies will result in the most cost-effective approach.

SECTION 10

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SECTION 12

DEFINITIONS OF TERMS AND ACRONYMS

AA	Atomic Absorption
BAT	Best Available Technology Economically Achievable
BCT	Best Conventional Pollution Control Technology
BMP	Best Management Practices
BPT	Best Practicable Control Technology
CFR	Code of Federal Regulations
CHT	Collection Holding and Transfer
COD	Chemical Oxygen Demand
CWA	Clean Water Act
DTIC	Defense Technical Information Center
ENR	Engineering News Record
EPA	Environmental Protection Agency
FWPCA	Federal Water Pollution Control Act
MIWP	Metropolitan Industrial Wastewater Program
NASSCO	National Steel and Shipbuilding Company
NPDES	National Pollutant Discharge Elimination System
NSPS	New Source Performance Standards
NSRP	National Shipbuilding Research Program
O&M	Operation and Maintenance
PAHs	Polynuclear Aromatics
POTW	Public Owned Treatment Works
PPB	Parts Per Billion
PPM	Parts Per Million
PSES	Pretreatment Standards for Existing Sources
PSNS	Pretreatment Standards for New Sources
QA/QC	Quality Assurance/Quality Control
RPD	Relative Percent Difference
RWQCB	Regional Water Quality Control Board
SWRB	State Water Resource Board
TBT	Tributyltin
TSDF	Treatment Storage and disposal Facility
TSS	Total Suspended Solids
TTO	Total Toxic Organics
UCSD	University of California San Diego
UF	Ultrafiltration

APPENDIX A
SHIPYARD HYDROBLAST WASTEWATER SURVEY

HYDROBLAST WASTEWATER SURVEY

NATIONAL STEEL AND SHIPBUILDING COMPANY
HARBOR DRIVE AND 28th STREET
POST OFFICE BOX 85278
SAN DIEGO, CA 92186-5278
ATTENTION BROOKE DAVIS, MS 20-J

Name of Shipyard:

Your Name and Position
Your Phone Number:

1. Please describe your hydroblasting operations; Is hydroblasting performed by A contractor or shipyard personnel?

2. What is the amount of hydroblast wastewater generated annually? (Average # Gallons/Vessel ? Estimate # Vessels hydroblasted?)

3. Please characterize the hydroblast wastewater in terms of sources, and chemical and physical nature of the contaminates. Please give an example list of elements and contaminates.

4. Do you contain the hydroblast wastewater runoff and, if so, how? How do you handle your storm water during hydroblasting or abrasive blasting operations? (Baker Tanks, large storage tanks, etc. and # gallons capacity of the containment vessels. Also please include information on your sump system and waste segregation)

5. Do you pretreat and/or treat hydroblast wastewater, and if so how were the methods selected and are other streams treated with these methods as well? Please give an example of pretreatment and treatment methods used.

6. What is the final fate of the hydroblast wastewater? Recycled or discharged to sewer or ocean.

7. What is the known or estimated cost to handle and manage hydroblast wastewater? (transportation, disposal, and treatment costs)

8. What are your future plans for handling and managing hydroblast wastewater?

9. What limits must your discharge wastewater meet? (City Limits, Metal Finishing Limits, etc.) What are your numerical limits for discharge?

APPENDIX B

VENDOR HYDROBLAST SURVEY

HYDROBLAST WASTEWATER SURVEY

NATIONAL STEEL AND SHIPBUILDING COMPANY
HARBOR DRIVE AND 28th STREET
POST OFFICE BOX 85278
SAN DIEGO, CA 92186-5278
ATTENTION BROOKE DAVIS, MS 20-J

Name of Your Company
Your Name and Position
Your Phone Number:

Please send catalogs and brochures, if available.

1. What are the primary business areas and the primary products of your company?

2. What percentage of the market does your technology type dominate and who are some of your customers?

3. Who are your major competitors?

4. What are the main parameters the customer needs to provide to you in order for you to assist him in selecting the optimal size and product to purchase? What are the main parameters, power rating, size of lines, hydraulic capacity, efficiency, etc., and capacity range of your equipment? (Attach general specifications if possible.)

5. How do your biggest selling products compete in price and what are the price ranges? Please give as specific quotes as possible.

6. What types of contaminates or particle size distribution does your treatment system remove and what percentage (can be a range) does the system remove?

7. What additional chemicals or equipment will your customer require? i.e. sludge dryer? pre-strainer, air stripper, monitoring and other instrumentation, etc. and do you sell this equipment also? If not, can you recommend some vendors of this equipment?

8. Describe the maintenance of your equipment that you recommend to your customer?

9. What are the primary benefits of your product to your customers?

APPENDIX C
REGULATORY OVERVIEW

REGULATORY OVERVIEW

The following is an excerpt from the EPA's Effluent Guidelines document, organized in outline form.

I. "The Federal Water Pollution Control Act Amendments of 1972 established a comprehensive program to, 'restore and maintain the chemical, physical, and biological integrity of the Nation's waters.' Section 101 (a)."

II. Requirements for Existing Industrial Dischargers

A. "By July 1,1977, existing industrial dischargers were required to achieve, 'effluent limitations requiring the application of the best practicable control technology currently available.' (BPT), Section 301 (b)(l)(A); and

B. By July 1,1983, these dischargers were required to achieve, 'effluent limitations requiring the application of the best achievable technology economically achievable. ... which will result in reasonable further progress toward the national goal of eliminating the discharge of all pollutants' (BAT), Section 301 (b)(2) (A)."

III. Requirements for New Direct and New Indirect Industrial Dischargers

A. "New industrial direct dischargers were required to comply with Section 306 new source performance standards (NSPS) based on Best Available Demonstrated technology; and

B. New and existing dischargers to POTWs, or indirect dischargers, were subject to pretreatment standards under Sections 307 (b) and (c) of the Act."

IV Enforcement

A. For direct dischargers, requirements were to be incorporated into NPDES permit issued under Section 402 of the Act, while

B. For dischargers to POTWs, pretreatment standards were made enforceable directly against them.

V. For Direct dischargers, "Congress intended that, for the most part, control requirements would be based on requirements promulgated by the Administrator of EPA.

A. Section 304(b) of the Act required the Administrator to promulgate regulations providing guidelines for effluent limitations setting forth the degree of effluent reduction attainable through the application of BPT and BAT.

B. Sections 304(c) and 306 of the Act required the Administrator to promulgate regulations for NSPS, and

C. Sections 304(f), 307(b), and 307(c) required the Administrator to promulgate regulations for pretreatment standards.

D. Section 307(a) of the Act required the Administrator to promulgate effluent standards applicable to all dischargers of toxic pollutants.

E. Finally Section 501(a) of the Act authorized the Administrator to prescribe any additional regulations, ‘necessary to carry out his functions.’

VIII.EPA did not promulgate many of these regulations by the dates contained in the act, and was sued by several environmental groups. The Court judged against the EPA in a settlement that required the EPA to, “adhere to a schedule for promulgating for 21 major industries for 65, ‘priority,’ pollutants and classes of pollutants,

1. BAT effluent limitations guidelines, and
2. pretreatment standards, and
3. new source performance standards”

IX. On December 27,1977, the Clean Water Act became law.

X. The CWA's most significant feature is emphasis on toxic pollution control.

A. “Sections 301(b)(2)(A) and 301(b)(2)(C) of the Act required achievement by July 1, 1984, of effluent limitations requiring application of BAT for, ‘toxic,' pollutants, including the 65, ‘priority,’ pollutants and classes of pollutants, including the 65 priority pollutants and classes of pollutants which Congress declared toxic under Section 307(a).”

B. “The EPA’S programs for new source performance standards and pretreatment standards are now aimed principally at toxic pollutant controls.”

C. “Section 304(e). . authorized the Administrator to prescribe,' Best Management Practices,’ (BMPs) to prevent the release of toxic and hazardous pollutants from plant site runoff, spillage or leaks, sludge or waste disposal, and drainage from raw material storage associated with, or ancillary to, the manufacturing or treatment process.”

XI. The”CWA also revised the control program for non-toxic pollutants.

A. “Instead of BAT for, ‘conventional,' pollutants identified under Section 304(a)(4) (including BOD, suspended solids, fecal coliform, and pH), the new Section 301(b)(2)(E) requires achievement of the best conventional pollutant control technology (BCT).”

B. "For nontoxic nonconventional pollutants, Sections 301(b)(2)(A) and (b)(2)(F) require achievement of BAT effluent limitations within three years after their establishment or July 1984, whichever is later, but not later than July 1,1984.

(This is where the 1977 EPA document ends and the Chemical Engineering Progress focus series article begins. While the EPA CWA overview focuses on industrial dischargers, the Chemical Engineering Progress article is broader in its overview. Only those issues not covered in the EPA document will be reviewed from the ChE article below.)

C. Nonconventional refers to, "pollutants that have been identified for control in specific industry effluent guidelines, but that are neither conventional pollutants nor listed as toxic pollutants."

I. The CWA, "establishes standards for POTWs, that include technologies required to control the quality of the effluent and pretreatment requirements for industrial discharges of toxic pollutants into the POTWs."

II. "It establishes technology based effluent standards for discharges into the waters of the United States (direct discharges) of conventional, pollutants, toxic pollutants, and nonconventional pollutants."

III. "For receiving waters that require special protection, it establishes water-quality based controls on discharges, which are more stringent than the technology based standards applicable to all discharges."

Iv. "It sets forth requirements for preventing and responding to accidental discharges of oil or hazardous substances into navigable waters, with notification requirements for releases, removal requirements, liability standards, and civil penalties."

v. "Finally, the Act establishes permitting programs to control discharges and sever civil and criminal enforcement provisions for failure to comply with the law."

VI. "The CWA provides that, 'except as in compliance with. . this Act, the discharge of any pollutant by any person shall be unlawful.' The phrase, 'discharge of any pollutant," is defined in part as, ' any addition of any pollutant to <u>navigable waters</u> from any <u>point source</u>.' The definition of navigable waters and point source are very broad." Congress primarily controls these discharges through the NPDES, a permit system designed to limit the discharge of pollutants into the nation's waterways.

VII. NPDES related discharges are those associated with industrial processes and the treatment of wastewater from a facility.

A. If the discharge is to a POTW, then the facility will be required to meet pretreatment standards to limit pollutants that cannot be readily removed by the

POTW. Discharges from the POTW will be in accordance with the effluent limitations contained in the NPDES permit for the POTW.

B. For discharges directly from the facility to receiving waters, the facility must have its own NPDES permit.

C. The NPDES permit is

1. facility wide, and
2. contains the effluent limitations applicable to each point source discharging from the facility and
3. incorporates the technology required to control the discharges.

D. The NPDES permit requires

1. periodic sample collection; either monthly or quarterly
2. Monitoring reports are filed with the EPA.
3. modification whenever new discharge points are added, new control technology is applied, or facilities become subject to new source performance standards.

VIII. State Programs

A. All states have enacted laws to control water pollution in their state.

B. The EPA may, and has oftentimes, delegated NPDES permitting authority to states who meet the requirements for delegation. As a result, facilities located in states that have received authority to administer the program are required to obtain only the state discharge permit.

APPENDIX D
ANALYTICAL RESULTS

ANALYTICAL CHEMISTS, INC.
8898-H Clairemont Mesa Blvd, San Diego, CA 92123 Voice & FAX (619) 560-4916

Nassco
P.O. BOX 85278
San Diego, CA 92186-5278

Attn: John Martin (Environmental)

LABORATORY # :445-93
DATE OF REPORT : August 16, 1993
DATE RECEIVED : August 16, 1993
DATE SAMPLED : August 16, 1993 (0900)
IDENTIFICATION :93-06-20 Sewer Connection 340

METHOD
Methods for the Chemical Analysis of Water and Wastes: EPA 600/4-79-020, and EPA SW-846.

RESULTS

TEST	UNITS	ALLOWED	RESULTS
pH	---	5-11	7.15
Copper	mg/L	2.07	0.66
Zinc	mg/L	1.48	3.0

NOTE: Anaiytes not detected are shown by < followed by our detection limit.

Paid
P. Roach 9/1/93

DATA :404-47
INVOICE :2185-W

David H. Elgas
Laboratory Director

RECD
AUG 18 1993
NATIONAL STEEL &
SHIPBUILDING
ACCTS PAY.

Laboratory Analytical Chemist Inc

NATIONAL STEEL AND SHIPBUILDING COMPANY

CHA!N . OF . CISTPDY RECORD

Client: NASSCO

Date: 8/16/93 *

Project Name: Sewer Connection 340

P.O. #:

Turnaround Time: __ Normal X Rush (24hrs) __ Emergency __ Other

Results Attn To: J. R. Martin

Due By:

Fax / Phone / Hard Copy

Phone:

Sampled by: J. R. Martin

FAX#:

Analysis: CN, CR, Cu, Pb, Ni, Ag, Zn, Cd, pH

Lab Sample I.D.	Client Sample I.D.	Date & Time	Grab or Composite	Sample Matrix	Location/Station	No of Containers	Type of Container	CN, CR, Cu	Pb, Ni, Ag	Zn, Cd	pH
93-06-20		8-16-93 8:00	G	Water	Sewer Conn 340	1	G/HSS	X	X	X	X

COMMENTS. Please Run Zn + Cu First 3/4 other Metals. They must pass Nation Finishing Limits Arui

Tape Seals Intact: Yes No

Received on Ics: Yes No

	RELINQUISHED BY	DATE & TIME	RECEIVED BY
1.	[signature]	8/16/93	
2.			
3.		8/16/93 9Am	Eric Elgas [signature]
4.			

Distribution: White–Accompanies Samples Pink–Sampler Retains

Printed on recycled paper

Pacific Treatment Analytical Services, Inc.
4340 Viewridge Avenue, Suite A-l San Diego. CA 92123 (619) 560-7717 FAX: (619) 560-7763

NASSCO
Harbor Drive a 28th Street
P.O. Box 85278
San Diego, CA 92168-5278
Attn: John Martin

LABORATORY NO:	1001-93
DATE OF REPORT:	August 19, 1993
DATE RECEIVED:	August 16, 1993 @ 1145
IDENTIFICATION :	PO NO: MU221768 Project: Barnicals From Hercules Spirits One solid sample

Enclosed with this letter is the report on the following analyses on the sample from the project identified above:

CAC Title 22 Metals digested by EPA 3010 and analyzed by EPA 6010, 7000 Series

The sample was received by Pacific Treatment Analytical Services intact, with chain-of-custody documentation and appropriate preservation. The test results and pertinent quality assurance/ quality control data are listed on the attached tables.

Comments: Sample subjected to Waste Extraction Technique (WET) prior to digestion.

JColumbo

Janis Columbo
Laboratory Director

BK 2421-150

NASSCO
Client Sample ID: 93-04-03
Lab Sample ID: 1001-93
Project: Barnicals-Hercules Spirits
Sample Matrix: Solid-STLC Extract
Attn: John Martin

Date Sampled: 08/16/93
Date Received: 08/16/93
Date Analyzed: 08/19/93
Date of Report: 08/19/93
Units: mg/L

RESULTS

Element	STLC Limits	Results
Copper	25	2 1
Zinc	250	42

Quality Assurance/Quality Control data for STLC

Parameter	MS%R	MSD % R	RPD
Copper	86	89	3
Zinc	87	90	3

MS % R = Matrix Spike Percent Recovery
MSD % R= Matrix Spike Duplicate Percent Recovery
RPD = Relative Percent Difference

Attorney Client Privilege...

NASSCO

NATIONAL STEEL AND SHIPBUILDING COMPANY

1001-93

CHAIN - OF - CUSTODY RECORD **24 HR**

Client: NASSCO

Date: 8-16-93

Project Name: Bracketals From Hercules AUG 18 1995

P.O. #

Turnaround Time: ___ Normal X Rush (24hrs) ___ Emergency ___ Other

Results Attn To: John R Martin Due By ___ Fax ___ Phone ___ Hard Copy Phone: 544-3400 x3553

Sampled by: John R Martin FAX#: 544-3542

Lab Sample ID	Client Sample ID	Date & Time	Grab or Composite	Sample Matrix	Location/Station	No of Containers	Type of Container	Analysis: STLC For Cu & Zn
93-04-03		8/16/93 8:15am	G	Solid	Hercules Sea Hull	1	Steel	X

COMMENTS. Results in 3 days.

Tape seals Intact Yes No NA

Received on Ice: Yes No

	RELINQUISHED BY	DATE & TIME	RECEIVED BY
1.	John R Martin	8/16/93	[signature] 10:26 8/16/93
2.	[signature]	8/16/93 11:10	[signature] 11:10am 8-16-93
3.			
4.			

Distribution: White—Accompanies Samples Pink—Sampler Retains

ANALYTICAL CHEMISTS, INC.

7535 Convoy court, San Diego, CA 92111 **Voice & FAX (619) 560-4916**

NASSCO)
PO Box 85278
San Diego, CA 92186-5278

Atnn: John Martin, Environmental

LAB SAMPLE # :481-1-93
DATE OF REPORT: September 8, 1993 (1311)
DATE RECEIVED : September 8, 1993 (0925)
DATE SAMPLED : September 8, 1993 (0800)
IDENTIFICATION : Baker Tank #1 93-06-24

METHOD
Methods for the Chemical Analysis of Water and Wastes: EPA 600/4-79-020, and EPA SW-846.

RESULTS

TESTI	UNITS	ALLOWED	RESULTS
Copper	mg/L	4.5	4.48
Zinc	mg/L	4.2	2.28

NOTE: Analytes not detected are shown by < followed by our detection limit.

David H. Elgas

David H. Elgas
Laboratory Director

DATA :404-57
INVOICE :2221-W

Paid P.Rowl
9/17/93

ANALYTICAL CHEMISTS, INC.
7535 Convoy Court, San Diego, CA 92111 Voice & FAX (619) 560-4916

NASSCO
PO Box 85278
San Diego, CA 92186-5278

Attn: John Martin, Environmental

LAB SAMPLE # : 481-2-93
DATE OF REPORT: September 8, 1993 (1311)
DATE RECEIVED : September 8, 1993 (0925)
DATE SAMPLED : September 8, 1993 (081O)
IDENTIFICATION : Baker Tank #2 93-06-25

METHOD
Methods for the Chemical Analysis of Water and Wastes: EPA 600/4-79-020, and EPA SW-846,

RESULTS

TEST	UNITS	ALLOWED	RESULTS
Copper	mg/L	4.5	3.47
Zinc	mg/L-	4.2	2.00

NOTE: Analytes not detected are shown by < followed by our detection limit.

David H. ElGas
Laboratory Director

DATA :404-57
INVOICE : 2221-W

Paid
P. [illegible]
9/17/93

A NALYTICAL C HEMISTS, IN C.
7535 Convoy Court, San Diego, CA 92111 Voice & FAX (619) 560-4916

NASSCO
PO Box 85278
San Diego, CA 92186-5278

Attn: Brooke Davis, Environmental

LAB SAMPLE # :607-1-93 Update
DATE OF REPORT Dec 8 & 29, 1993
DATE RECEIVED : November 22, 1993
DATE SAMPLED : November 22, 1993
IDENTIFICATION : Hydroblast water study
Composite AC-Sump

METHOD
A series of 2 bottles (1 liter) were received. The 2 samples were AO-Sump 01 and AO-Sump 02. The samples were composited (equal volumes) to produce a single “raw” composite which we called AC-SUMP. That composite was shaken well, and a Portion was quickly removed for analysis; the data are “Totals”. After allowing the raw supsample to settle for 60 minutest a Portion of the supernatant layer was filtered through a 0.45 micron membrane filter to remove all suspended solids. That clear filtrate was then analyzed to characterize the solubles.

RESULT
Total means all soluble substances PIUS all particles (suspended as well as those larger panicles which might ordinarily settle out). Supenatant means only the soluble substances Plus those that stay suspended. Soluble means only those that pass through a 0.45 micron membrane filter.

TEST	UNITS	TOTAL	SUPERNATANT	SOLUBLE
P^H		7.1	---	
Arsenic	mg/L	<0.03	---	
Barium	mg/L	---	---	---
Cadmium	mg/L	-.-	---	---
Chromium	mg/L	-0-		-0-
Copper	mg/l	19.4	---	3.2
Iron	mg/L	11.9	---	---
Lead	mg/L		---	---
Manganese	mg/L		---	
Nickel	mg/L	---	---	---
Tin	mg/L	2.2	---	---
Zinc	mg/L	6.6		0.6
Oil & Grease	mg/L	1010.	---	
COD	mg/L			---
TSS	mg/L			
Vss	mg/L			---

DATA :404-121
INVOICE : 2347-W

David H. Elgas
Laboratory Director

ANALYTICAL CHEMISTS, INC.

7535 convoy Court San Diego CA 92111 Voice & FAX (619) 560-4916

NASSCO
PO Box 85278
San Diego, CA 92186-5278

Attn: Brooke Davis, Environmental

LAB SAMPLE # : 607-3to17-93 Update
DATE OF REPORT: Dec 8 & 29, 1993
January 26, 1994
DATE RECEIVED : November 22, 1993
DATE SAMPLED : November 22, 1993
IDENTIFICATION : Hydroblast water study
Composite = AC-FalI

METHOD

A series of 15 bottles (1 liter) were received. The 14 of the bottles were pairs of A#-Fall-01 and Fall-02. The A#s were: Al, A2, A5, A6, A7, A8, and A11. A single sample called AlO-Fali-01 was also included. These samples were composite (equal volumes) to Produce a single composite which we called AC-FALL. That composite was analyzed directly. Another aliquot of the AC-FALL composite was allowed to settle for 60 minutes to determine the settleable solids content) and to isolate the sediment for particle characterization. The supernatant layer from this test was isolated for selected analyses.

RESULTS

Total means all soluble substances plus all particles (Suspended as Well as those larger particles which might ordinarily settle out). Supernatant mean only the soluble substances Plis those that stay Suspended. Soluble means only those that pass through a 0.45 micron membrane filter.

TEST	UNITS	TOTAL	SUPERNATANT	SOLUBLE
pH		4.2	---	- - -
Barium	mg/L-	< 1.0		
C dm m	mg/L	<0.05	----	
Chromium	mg/L	0.2		-0-
Copper	mg/L	44.1		2.5
Iron	mg/L	14.2	---	0.13
Lead	mg/L	<0.1		---
Manganese	mg/L	0.08		-0-
Nickel	mg/L	3.9	-.-	<0.05
Tin	mg/L	< 2.0		-0-
Zinc	mg/L	23.6	---	2.6
COD	mg/L	---	371.0	---
Settleables	CC/L	5.0		---
TSS	mg/L		335.0	
VSS	mg/L		180.0	---
FSS	mg/L		155.0	

DATA :404-121
INVOICE : 2347-W

David H. Elgas
l-aboratoy Director

ANALYTICAL CHEMISTS, INC.

7535 Convoy Court, San Diego, CA 92111 Voice & FAX (619) 560-4916

NASSCO
PO Box 85278
San Diego, CA 92186-5278

Attn: Brooke Davis, Environmental

LAB SAMPLE # : 607-18,19-93 Update
DATE OF REPORT: Dec 8 & 29, 1993
DATE RECEIVED : November 22, 1993
DATE SAMPLED : November 22, 1993
IDENTIFICATION : Hydroblast water study
Composite = A15C-Fall

METHOD

A series of 2 bottles (1 liter) were received. The bottles were called A15-FALL 01 and A15-FALL 02. The samples were composited (equal volumes) to produce a single composite which we called A15C-FALL. That composite was analyzed directly.

RESULTS

Total means all soluble substances plus *all particles* (suspended as well as those larger particles which might ordinarily settle out). Supernatant means only the soluble substances plus those that stay suspended. Soluble means only those that pass through a 0.45 micron membrane filter.

TEST	UNITS	TOTAL	SUPERNATANT	SOLUBLE
pH	---	4.2	-.-	-.-
Barium	mg/L	-.-	-.-	-.-
Cadmium	mg/L	-.-	-.-	-.-
Chromium	mg/L	-.-	-.-	-.-
Copper	mg/L	< 0.05	-.-	-.-
Iron	mg/L	-.-	-.-	-.-
Lead	mg/L	-.-	-.-	-.-
Manganese	mg/L	-.-	-.-	-.-
Nickel	mg/L	-.-	-.-	-.-
Tin	mg/L	-.-	-.-	-.-
Zinc	mg/L	< 0.05	-.-	-.-
COD	mg/L	-.-	-.-	-.-
TSS	mg/L	-.-	-.-	-.-
VSS	mg/L	-.-	-.-	-.-

David H. Elgas

DATA : 404-121
INVOICE : 2347-W

David H. Elgas
Laboratory Director

ANALYTICAL CHEMISTS, INC.

7535 Convoy Court, San Diego, CA 92111 **Voice & FAX (619) 560-4916**

NASSCO
PO B0X 85278
San Diego, CA 92186-5278

Attn: Brooke Davis, Environmental

LA8 SAMPLE # :607-20,21-93 Upadate
DATE OF REPORT: Dec 8 & 29, 1993
DATE RECEIVED : November 22, 1'993
DATE SAMPLED : November 22, 1993
IDENTIFICATiON : Hydroblast water study
Composite = AC-Nozzle

METHOD

A series of 2 bottles (1 liter) Were received. The bottles were called NOZZZLE 01 and NOZZLE 02. The samples were mixed (equal voiumes) to Produce a single composite which we calied AC-NOZZLE. The composite was analyzed directly.

RESULTS

Total means all soluble substances plus all particles (suspended as well as those larger particles which might ordinarily settle out). Supernatant means only the soluble substances plus those that stay suspended. Soluble means only those that pass through a 0.45 micron membrane filter.

TEST	UNITS	TOTAL	SUPERNATANT	SOLUABLE
pH		8.1		
Barium	mg/L	---		
Cadmium	mg/L	---		
Chromium	mg/L	---		
Copper	mg/L	<0.05		
Iron	mg/L	---		
Lead	mg/L	---		
Manganese	mg/L	-		
Nickel	mg/L	---		
Tin	mg/L	---		
Zinc	mg/L.	0.2		
COD	mg/L	---		
TSS	mg/L	---		
Vss	mg/L	---		

DATA :404-121
INVOICE : 2347-W

David H. Elgas
Laboratory Director

	Ba	Cd	Cr	Cu	Fe	Mn	NI	Pb	Sn	Zn
607-AC- Fall	<1.0	<0.05	<0.05	42.8	11.5	0.07	1.6	<0.1	<2.0	22.6
607-AC- Fall Dup	4.0	<0.05	0.2	45.5	16.9	0.097	6.1	<0.1	<2.0	24.5
Average	<1.0	<0.05	0.2	44.1	14.2	0.06	3.9	4.1	<20	23.6
%RPD	n/a	n/a	n/a	6%	37%	32%	115%	n/a	n/a	8%
607-A1 SC- Fall				<0.05						<0.05
607-AC-Sump raw				19.4						6.6
607-AC-Sump Filtered				3.2						0.6
607-AC-Nozzle				<0.05						0.2

QA

	Ba	cd	Cr	Cu	Fe	Mn	Ni	Pb	Sn	Zn
Check Std .	101%	100	103%	104%	111%	106%	102%	98%	96%	104%
607-A1SC-Fall Spk	74%	112%	129%	108%	111%	138%	122%	107%	99%	115%
807-A1SC-Fail SD	69%	110%	177%	107%	137%	140%	124%	101%	145%	111%
%RPD	7%	2%	10%	1%	19%	1%	2%	6%	38%	4%

	TSS	VSS	COD	Settaable Solids
607-ACFall- Supernatant	335 Mg/L	155 Mg/L	371 Mg/L	5 ml/L

ANALYTICAL CHEMISTS, INC.

7535 Convoy Court, San Diego, CA 92111 Voice & FAX (619) 560-4916

NASSCO
PO Box 85278
San Diego, CA 92186-5278

Attn:Brooke Davis, Environmental

LAB SAMPLE # :114-94“
DATE OF REPORt: anuary 24, 1994
DATE RECEIVED : January 101994 (1147).
DATE SAMPLED : January 10, 1994
IDENTIFICATION :.NSRP Water Filtration Study I
Composite of Tank / Princess
94-T-01 ,02,03,04,0506

METHOD
A series of 6 bottles (1 liter) were received. These 6 bottles were used to prepare a composite which yielded the data below.

RESULTS
Total means all soluble substances plus *all particles* (suspended as well as those larger particles which might ordinarily settle out). Supernatant means only the soluble substances plus those that stay suspended. Soluble means only those that pass through a 0.45 micron membrane filter.

TEST	UNITS	TOTAL	SUPERNATANT	SOLUBLE
pH	---	7.04		
Barium	mg/L	< 1.0		
Cadmium	mg/L	< 0.05		-.-
Chromium	mg/L	< 0.05		-.-
Copper	mg/L	2.29		0.85
Iron	mg/L	9.23		< 0.05
Lead	mg/L	< 0.1		
Manganese	mg/L	0.50		
Nickel	mg/L	0.44		
Tin	mg/L	< 3.0		
Zinc	mg/L	1.21		
Oil & Grease	mg/L	-.-	9.7	-.-
COD	mg/L	-.-	863.0	-.-
Settleables	cc/L	< 0.2	-.-	-.-
TSS	mg/L	-.-	49.0	-.-
VSS	mg/L	-.-	38.0	-.-
FSS	mg/L	-.-	11.0	-.-

DATA : 405-15
INVOICE : 2414-W

David H. Elgas
Laboratory Director

ANALYTICAL CHEMISTS, INC.
7535 Convoy Court, San Diego, CA 92111
Voice & FAX (619) 560-916

NASSCO
PO BOX 85278
San Diego, CA 92186-5278

Attn: Brooke Davis, Environmental

LAB SAMPLE # : 159-(2,3,4)-94
DATE OF REPORT March 1 & 7, 1994
DATE RECEIVED : January 25, 1994
DATE SAMPLED : January 25, 1994
IDENTIFICATION : NSRP Water Filtration Study
Viking Seranade Composite
01, 02, 03

METHOD
A series of 3 bottles (1 liter) were received. These 3 bottles were used to prepare a composite which yielded the data below. Analytical methods are from EPA 600/4-79-020, Methods for the Chemical Analysis of Water and Wastes.

RESULTS
Total means all soluble substances plus *all particles* (suspended as well as those larger particles which might ordinarily settle out). Supernatant means only the soluble substances plus those that stay suspended. Soluble means only those that pass through a 0.45 micron membrane filter.

TEST	UNITS	TOTAL	SUPERNATANT	SOLUBLE
pH	---	8.32		
Arsenic	mg/L	0.008		
Barium	mg/L	< 1.0		
Cadmium	mg/L	< 0.05		
Chromium	mg/L	< 0.05		
Copper	mg/L	11.0		
Iron	mg/L	38.0		
Lead	mg/L	< 0.1		
Manganese	mg/L	0.29		
Nickel	mg/L	0.29		
Silver	mg/L	< 0.05		
Tin	mg/L	< 3.0		
Zinc	mg/L	12.0		
Oil & Grease	mg/L	< 1.0	-.-	-.-
COD	mg/L	-.-	374.0	-.-
Settleables	cc/L	1.5	-.-	-.-
TSS	mg/L		490.0	-.-
VSS	mg/L		229.0	-.-
FSS	mg/L		262.0	-.-

DATA : 405-40
INVOICE : 2459-W

David H. Elgas
David H. Elgas
Laboratory Director

ANALYTICAL CHEMISTS, INC.

7535 Convoy Court, San Diego, CA 92111 Voice & FAX (619) 560-4916

NASSCO
PO Box 85278
San Diego, CA 92186-5278

Attn: Brooke Davis, Environmental

LAB SAMPLE # : 159-1-94
DATE OF REPORT: March 1 & 7, 1994
DATE RECEIVED : January 25, 1994
DATE SAMPLED : January 25, 1994
IDENTIFICATION : NSRP Water Filtration Study I Sump

METHOD

Only one bottle was received. Analytical methods are from EPA 600/4-79-020, Methods for the Chemical Analysis of Water and Wastes.

RESULTS

Total means all soluble substances plus *all particles* (suspended as well as those larger particles which might ordinarily settle out). Supernatant means only the soluble substances plus those that stay suspended. Soluble means only those that pass through a 0.45 micron membrane filter.

TEST	UNITS	TOTAL	SUPERNATANT	SOLUBLE
pH	—	7.40		-.-
Arsenic	mg/L	0.009		-.-
Barium	mg/L	1.7		-.-
Cadmium	mg/L	< 0.05		-.-
Chromium	mg/L	0.24		-.-
Copper	mg/L	13.0		0.44
Iron	mg/L	181.0		< 0.05
Lead	mg/L	< 0.1		-.-
Manganese	mg/L	0.62		-.-
Nickel	mg/L	0.19		-.-
Silver	mg/L	< 0.05		-.-
Tin	mg/L	< 3.0		-.-
Zinc	mg/L	1.4		0.14
Oil & Grease	mg/L	< 5.0 *	-.-	
COD	mg/L	-.-	356.0	
Settleables	cc/L	0.6	-.-	
TSS	mg/L	202.0	194.0	
VSS	mg/L	-.-	76.0	
FSS	mg/L	-.-	118.0	

Sample limited to 100 ml for Oil + Grease.

DATA : 405-40
INVOICE : 2459-W

David H. Elgas
David H. Elgas
Laboratory Director

ANALYTICAL CHEMISTS, INC.

7535 Convoy Court, San Diego, CA 92111 Voice & FAX (619) 560-4916

NASSCO
PO Box 85278
San Diego, CA 92186-5278

Attn: Brooke Davis, Environmental

LAB SAMPLE # :159-5-94
DATE OF REPORT March 1 & 7, 1994
DATE RECEIVED : January 25, 1994
DATE SAMPLED : January 25, 1994
IDENTIFICATION : NSRP Water Filtration Study I
Viking Seranade; Nozzle

METHOD

One bottle (1 liter) was received. Analytical methods are from EPA 600/4-79-020, Methods for the Chemical Analysis of Water and Wastes.

RESULTS

Total means all soluble substances Plus all particles suspended as well as those larger particles which might ordinarily settle out). Supernatant means Only the soluble substances PIUS those that stay suspended. Soluble means only those that pass through a 0.45 micron membrane filter.

TEST	UNITS	TOTAL	SUPERNATANT	SOLUBLE
pH	---	8.23		
Arsenic	mg/L	-.-		
Barium	mg/L	-.-		
Cadmium	mg/L	-.-		
Chromium	mg/L	< 0.05		
Copper	mg/L	< 0.05		
Iron	mg/L	-.-		
Lead	mg/L	-.-		
Manganese	mg/L	-.-		
Nickel	mg/L	< 0.05		
Silver	mg/L	-.-		
Tin	mg/L	-.-		
Zinc	mg/L	< 0.05		
Oil & Grease	mg/L			
COD	mg/L			
Settleables	cc/L			
TSS	mg/L			
VSS	mg/L			
FSS	mg/L			

DATA :405-40
INVOICE : 2459-W

David H. Elgas
Laboratory Director

ANALYTICAL CHEMISTS, INC.

7535 Convoy Court, San Diego, CA 92111 Voice & FAX (619) 560-4916

NASSCO
PO Box 85278
San Diego, CA 92186-5278

Attn: Brooke Davis, Environmental

LAB SAMPLE # :159-6-94
DATE OF REPORT March 1 &7, 1994
DATE RECEIVED : January 25, 1994
DATE SAMPLED : January 25, 1994
IDENTIFICATION : NSRP Water Filtration Study I
Viking Seranade; composite

METHOD

Two bottles (1 liter) were received. These 2 bottles were used to prepare a composite which yielded the data below. Analytical methods are from EPA 600/4-79-020, Methods for the Chemical Analysis of Water and Wastes.

RESULTS

Total means all soluble substances PIUS all particles (suspended as well as those larger particles which might ordinarily settle out). Superbatant means only the soluble substances PIUS those that stay suspended. Soluble means only those that pass through a 0.45 micron membrane filter.

TEST	UNITS	TOTAL	SUPERNATANT	SOLUBLE
pH		6.99		
Arsenic	mg/L	-.-		
Barium	mg/L	-.-		
Cadmium	mg/L	-.-		
Chromium	mg/L	< 0.05		
Copper	mg/L	< 0.05		
Iron	mg/L	-.-		
Lead	mg/L	-.-		
Manganese	mg/L	-.-		
Nickel	mg/L	< 0.05		
Silver	mg/L	-.-		
Tin	mg/L	-.-		
Zinc	mg/L	< 0.05		
Oil & Grease	mg/L			
COD	mg/L			
Settleables	cc/L			
TSS	mg/L			
VSS	mg/L			
FSS	mg/L			

David H. Elgas

David H. Elgas
Laboratory Director

DATA :40540
INVOICE : 2459-W

APPENDIX E
MARITIME INDUSTRIAL WASTE PROJECT
DESCRIPTIONS OF PILOT-TESTED TREATMENT SYSTEMS

12. Appendix: Descriptions of Treatment Systems That Were Pilot-tested During the Maritime Industrial Waste Project

Filtration - Mixed Media

Process Description

This system is a commercially available continuous-flow mixed-media filter. The system is composed of a pressure vessel that holds the filter media and the piping and valves necessary for operation. The filter media is composed of layers of coal, coarse sand and fine sand. Untreated wastewater is pumped through the filter media, and the clarified water is discharged to sanitary sewers. When the filter becomes plugged, a backwash cycle scrubs the collected contaminants from the filter media and into a backwash tank or sump.

The system removed particulates effectively, but the untreated wastewater was very low in particulate contarminants. In other tests involving higher contaminant loads, the system was found to plug rapidly, requiring a volume of backwash . water greater than the wastewater filtered. This system is best used as a final-polish filtration step that follows settling or chemical flocculation.

Operation and Maintenance

The system operates continuously without attention until a backwash cycle is needed.

The system requires routine maintenance for the backwash cycle. Several valves must be turned manually to activate and deactivate the backwash cycle.

Table A-1: Filtration – Mixed Media [1]
(All units except pH in mg/l)

Analytical Parameter	Untreated Sample (average)	Treated Sample (average)	Percent Reduction (average)	Treated Sample (high)	Under Limits? [2] Sewers (Metro)	Under Limits? [2] Receiving Waters
pH	7.6	7.3	—	7.3	YES	YES
Suspended solids	22	10	55	10	[3]	YES
Copper	0.12	0.02	83	0.02	YES	NO
Lead	<0.03	<0.03	—	<0.03	YES	YES
Zinc	1.2	0.22	82	0.22	YES	NO
Arsenic	<0.05	<0.05	—	<0.05	YES	YES

Note: Tests were conducted at Marco Seattle Inc., Seattle.
[1] Values based on one test.
[2] Determined by comparing highest value from treated samples to limit values.
[3] No limit set for this parameter.

Membrane Filtration – Ultrafiltration

Process Description

The system's main components are a recirculation tank membrane tubes and a process pump. Untreated wastewater is pumped to a 50-gallon recirculation tank. The wastewater is pumped through membrane tubes at a pressure of 40 to 60 pounds per square inch and back to the recirculation tank A portion of the wastewater, called the permeate, passes through the membrane and is discharged. A level-control maintains wastewater flow to the recirculation tank as needed. The volume of wastewater is reduced and concentrated in the recirculation tank A concentration ratio of 20 to 40 times is ordinarily achievable.

This process produced treated wastewater that easily met sewer discharge limits in all tests.

Operation and Maintenance

The operation of the system is continuous and automatically regulated. Only start-up adjustments are necessary. A holding tank is needed because process flow rates are generally less than the wastewater flows generated.

The system does require routine maintenance to clean the membranes. This maintenance is usually done by circulatig a cleaning solution through the membranes after each processing event. Membranes need *to* be replaced when process flow rates decline as a result of irreversible membrane fouling,

Table A-2: Membrane Filtration – Ultrafiltration [1]
(All units except pH in mg/l)

Analytical Parameter	Untreated Sample (average)	Treated Sample (average)	Percent Reduction (average)	Treated Sample (high)	Under limits? [2] Sewers (Metro)	Under limits? [2] Receiving Waters
pH	7.3	7.3	---	6.9 - 7.8	YES	YES
Suspended solids	85	[4]	---	[4]	[3]	YES
Copper	5.3	0.1	97	0.3	YES	NO
Lead	0.2	<0.1	---	<0.03	YES	YES
Zinc	1.8	0.1	92	0.3	YES	NO
Arsenic	<0.1	<0.05	---	<0.05	YES	YES

Note: Tests were conducted at United Marine Shipbuilding Inc., Seattle.
[1] Values from five tests.
[2] Determined by comparing highest value from treated samples to limit values.
[3] No iimit set for this parameter.
[4] Not determined, because no visible suspended solids detected.

Filtration – Media Precoat

Process Description

This commercially available system operates in a continuous mode. The tested model has a treatment capacity of eight gallons per minute. The basic components of the system area precoat filter unit, a body-feed injection system, piping valves and a pump. The system operates by filtering wastewater through a thin layer of diatomaceous earth supported on fabric. When the filter begins to plug with contaminants, it is backwashes to remove the plugged media. New media is applied by running a slurry of fresh media through the filter. To avoid rapid pluging a small amount of the filter media is introduced into the waste stream before filtering. This body-feed, as it is called, makes the particulate more porous as they are collected on the filter media and maximizes filter capacity.

Results from two tests showed a substantial reduction of suspended solids. However, copper was not reduced to below the sewer discharge limit. This lack of reduction is unusual since the observed reduction in solids would ordinarily mean lower copper concentrations. Further tests are necessary to confirm the predicted effectiveness of this system.

Operation and Maintenance

The tested system was manually operated. Its operation requires start-up and monitoring. Occasional backwashing which involves operating several values, is necessary. To make the slurry, filter media need to be measured out. Operational requirements could be reduced on a production model with semi-automatic controls and automatic values.

Maintenance requirements include replenishing and storing the filter media and conducting routine cleaning and maintenance of the system hardware.

Table A-3: Filtration – Media Precoat [1]
(All units except pH in mg/l)

Analytical Parameter	Untreated Sample (average)	Treated Sample (average)	Percent Reduction (average)	Treated Sample (high)	Under Limits? [2] Sewers (Metro)	Under Limits? [2] Receiving Waters
pH	7.4	7.5	---	7.3 - 7.5	YES	YES
Suspended solids	221	18	92	29	[3]	YES
Copper	3.1	2.5	19	4.0	NO	NO
Lead	<0.03	<0.03	---	---	YES	YES
Zinc	0.6	.4	33	0.5	YES	NO
Arsenic	<0.05	<0.05	---	---	YES	YES

Note: Tests were conducted at Todd Shipyard Corp., Seattle.
[1] Values from three tests using diatomaceous earth precoat media.
[2] Determined by comparing highest value from treated samples to limit values.
[3] No limit set for this parameter.

Settling and Filtration Manufactured Mixed Media, System 1

Process Description

The main components in this commercially available system are an oil-water separator and settling chamber, activated carbon filter and mixed-media filter. As wastewater is circulated through the system, particulate are removed by gravity in the settling chamber and by filtration in the mixed-media filter. The system comes with pumps, piping and controls. A wastewater sump *or* holding tank is required.

Only one test was performed on this system. The volume of wastewater was not enough to fill the system completely, and the effluent may have been highly diluted with city-supptied water. The system is designed to remove wastewater particulate. Further tests of the system are needed.

Operation and Maintenance

The system operates in an automatic mode when fully operation. The system's level controls maintain proper flows.

The system requires routine backwashing and filter-cleaninig. Sludge accumulations also need to be removed routinely from the settling chamber. Some occasional wash-down of the whole system may be required to prevent excessive biological growth.

Table A-4: Settling and Filtration – Manufactured Mixed-media System [1]
(All units except pH in mg/l)

Analytical Parameter	Untreated Sample (average)	Treated Sample (average)	Percent Reduction (average)	Treated Sample (high)	Under Limits? [2] Sewers (Metro)	Under Limits? [2] Receiving Waters
pH	7.2	7.4	---	7.4	YES	YES
Suspended solids	700	15	98	15	[3]	YES
Copper	35	0.22	99	0.22	YES	NO
Lead	0.1	---	---	---	YES	YES
Zinc	3.7	0.17	95	0.17	YES	NO
Arsenic	---	---	---	---	YES	YES

Note: Tests were conducted at Fishermen's Boat Shop Inc., Everett.
[1] Values from one test.
[2] Determined by comparing highest value from treated samples to limit values.
[3] No limit set for this parameter.

Settling and Filtration – Manufactured Mixed Media, System 2

Process Description

The main components in this commercially available system are an oil-water separator and settling chamber, mixed-media filter, cartridge filter and activated carbon filter. As the wastewater is circulated through the system, . particulate are removed by gravity in the settling chamber and by filtration in the mixed-media and cartridge filters. The system comes with pumps, piping and controls. A wastewater sump or holding tank is required.

Only one test was performed on relatively clean wastewater in this system. The system reduced particulate contamination significantly and is expected to do so at higher particulate loadings.

Operation and Maintenance

The system operates in an automatic mode - when fully operational. The system's level controls maintain proper flows.

The system requires routine backwashing and filter- cleaning. Sludge accumulations also need to be removed routinely from the settling chamber. Some occasional wash-down of the whole system may be required to prevent excessive biological growth.

Table A-5: Settling and Filtration – Manufactured Mixed-media System [1]
(All units except pH in mg/l)

Analytical Parameter	Untreated Sample (average)	Treated Sample (average)	Percent Reduction (average)	Treated Sample (high)	Under Limits? [2]	
					Sewers (Metro)	Receiving Waters
pH	6.8	7.3	---	6.8 - 7.3	YES	YES
Suspended solids	34	13	62	13	[3]	YES
Copper	2.5	0.44	82	0.44	YES	NO
Lead	0.1	0.06	---	0.06	YES	YES
Zinc	1.1	0.13	88	0.13	YES	NO
Arsenic	<0.1	<0.05	---	<0.05	YES	YES

Note: Tests were conducted at Seaview East Boatyard, Seattle.
[1] Values based on one test.
[2] Determined by comparing highest value from treated samples to limit values.
[3] No limit set for this parameter.

[redacted]ical Flocculation and Settling – Alum and Lime

Process Description

This batch process can be carried out in a plastic 35-gallon garbage can. About 0.5 grams/liter of alum is added to wastewater in a batch treatment tank The solution is mixed for several minutes. About 1 gram/liter of lime is then added to raise the pH to about 8. The pH is checked with pH paper, and *more lime is* added as needed. The solution is again mixed for several minutes and allowed to settle for 30 minutes. The clarified wastewater is then decanted and discharged to the sewers.

The sewer discharge limits were met for all tests performed. In several preliminary tests, lime was not added to *raise the* pH, and metal concentrations were considerably higher than the allowed limits. Raising the pH above 7 is critical for successful treatment.

Operation and Maintenance

The operation requires measuring and mixing chemicals, draining the clear solution for discharge, and removing the sludge for later dewatering and disposal. Only one tank is needed for the process.

Maintenance requirements include purchasing chemicals and storing them correctly.

[redacted]

Table A-6: Chemical Flocculation – Alum and Lime [1]
(All units except pH in mg/l)

Analytical Parameter	Untreated Sample (average)	Treated Sample (average)	Percent Reduction (average)	Treated Sample (high)	Under Limits? [2]	
					Sewers (Metro)	Receiving Waters
pH	7.3	8.6	---	11.8	YES	NO
Suspended solids	415	82	80	110	[3]	NO
Copper	42	0.6	99	0.84	YES	NO
Lead	1.3	0.06	95	0.09	YES	YES
Zinc	5.7	0.16	97	0.26	YES	NO
Arsenic	<0.05	<0.05	---	<0.05	YES	YES

Note: System was developed at Miller and Miller Boatyard, Seattle.
1] Values from three tests.
2] Determined by comparing highest value from treated samples to limit values.
3] No limit set for this parameter.

Chemical Flocculation – Cationic Polymer

Process Description

The main components in this yard-developed, continuous treatment system are a chemical metering pump, mixing unit and settling tank. A flocculating polymer is metered into and mixed with wastewater as it flows into a settling tank. The polymer forms floc with wastewater particles, and the floe settles out in the settling chamber. Clarified wastewater is decanted *from the* settling tank and discharged to the sanitary sewers. The system is capable of treating 30 gallons per minute.

This system produced treated effluent consistently below the sewer discharge limits.

Operation ● and Maintenance

The system operates in an automatic mode. Operator attention is required for start-up and system monitoring.

Maintenance requirements include adjusting and maintaining the metering pump, system transfer pumps and level controls. The sludge level needs to be monitored in the settling tank, and the sludge needs to be removed when necessary.

Table A-9: Chemical Flocculation – Cationic Polymer [1]
(All units except pH in mg/l)

Analytical Parameter	Untreated Sample (average)	Treated Sample (average)	Percent Reduction (average)	Treated Sample (high)	Under Limits? [2]	
					Sewers (Metro)	Receiving Waters
pH	7.5	6.9	—	6.6 - 7.3	YES	YES
Suspended solids	221	17	92	34	[3]	YES
Copper	16	0.7	95	1.3	YES	NO
Lead	0.6	<0.03	—	0.04	YES	YES
Zinc	9.4	1.3	86	1.8	YES	NO
Arsenic	<0.2	<0.05	—	<0.05	YES	YES

Note: Tests were conducted at Lake Union Drydock Co., Seattle.
[1] Values from seven tests.
[2] Determined by comparing highest value from treated samples to limit values.
[3] No limit set for this parameter.

[redacted]lved-air Flotation – Continuous Alum Flocculation System

Process Description

This commercially available system operates continuously with a treatment capacity of 24 gallons per minute. The basic components are chemical metering pumps, a chemical mixing unit, a dissolved-air generator, a clarifier tank and a rotating sludge skimmer. Alum and a polymer are used to flocculate wastewater particles, and dissolved air is introduced to a clarifier to float the floc. The floating sludge is continuously removed by a rotating skimmer. Clarified wastewater is removed from the clarifier and discharged to the sanitary sewers.

Sewer discharge limits were met for the two tests performed. In both tests, the untreated wastewater was relatively low in metal contamination. The percentage reduction in contaminants is expected to be similar in wastewater with higher metal contamination levels.

Operation ● and Maintenance

The operation requires start-up, adjustments and monitoring. Chemical addition requires mixing chemical solutions and adjusting metering pumps.

Maintenance requirements include replenishing and storing chemicals and conducting routine cleaning and maintenance of the system hardware.

Table A-10: Dissolved-air Flotation – Continuous Alum Flocculation System [1]
(All units except pH in mg/l)

Analytical Parameter	Untreated Sample (average)	Treated Sample (average)	Percent Reduction (average)	Treated Sample (high)	Under Limits? [2]	
					Sewers (Metro)	Receiving Waters
pH	7.2	5.6	---	5.0 - 6.1	YES	NO
Suspended solids	113	37	67	44	[3]	NO
Copper	1.8	0.6	67	0.8	YES	NO
Lead	<0.03	<0.03	---	<0.03	YES	YES
Zinc	2.5	2.0	20	2.9	YES	NO
Arsenic	<0.05	<0.05	---	<0.05	YES	YES

Note: Tests were conducted at Duwamish Shipyard Inc., Seattle.
[1] Values from two tests.
[2] Determined by comparing highest value from treated samples to limit values.
[3] No limit set for this parameter.

[redacted]d-air Flotation – Alum Batch System

Process Description

The main components in this commercially available system are a reactor/flotation tank, induced-air supply pump and solids-collection filter tray. Alum, lime and a polymer are added to achieve flocculation. Air is introduced by recirculating the solution through a pump, which draws in air and mixes it with the solution. The pump is then shut off, and the floc is allowed to rise with attached air bubbles. The clear solution and floating flocs are drained to a filter below the tank, and the filtered water is discharged to the sanitary sewers.

Several tests were performed on this system, but only one was chemically analyzed. In the analyzed test, the system achieved effluent quality sufficient for discharge to sanitary sewers. In other tests, problems in achieving consistent flotation of the chemically formed floc were encountered. Flotation problems, which may have been caused by an undersized pump on the pilot unit, are reported not to occur on full-scale units. Further testing of the system is needed *to* establish whether consistent flotation is possible.

Operation and Maintenance

The system operates in a batch mode. Chemical addition and solution transfer were performed manually on the pilot unit but could be performed automatically on a production system at increased cost. The filter position and method for removing the filter on the pilot unit made handling the sludge difficult.

Maintenance requirements include purchasing and storing treatment chemicals.

[redacted]

Table A-11: Induced-air Flotation – Alum Batch System [1]
(All units except pH in mg/l)

Analytical Parameter	Untreated Sample (average)	Treated Sample (average)	Percent Reduction (average)	Treated Sample (high)	Under Limits? [2]	
					Sewers (Metro)	Receiving Waters
pH	7.0	8.1	—	8.1	YES	NO
Suspended solids	520	44	92	44	[3]	YES
Copper	6.6	0.15	98	0.15	YES	NO
Lead	0.2	<0.03	—	<0.03	YES	YES
Zinc	9.8	0.1	99	0.1	YES	NO
Arsenic	0.07	<0.05	—	<0.05	YES	YES

Note: Tests were performed at Marco Seattle Inc., Seattle.
[1] Values based on one test.
[2] Determined by comparing highest value from treated samples to limit values.
[3] No limit set for this parameter.